

UNDERGROUND STORAGE TANK SYSTEM CORRECTIVE ACTION PLAN OUTLINE



NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DIVISION OF WASTE MANAGEMENT
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INTRODUCTION

This document shall be used by owners and operators that are required to develop and implement a corrective action plan (CAP) under Kentucky Administrative Regulations 401 KAR 42:060. This outline applies to owners and operators that have submitted a Notice of Intent to Permanently Close UST's Form (DEP5025/07/95) or have reported a release to the Cabinet on or after January 1, 1996. Owners and operators shall submit a CAP upon acceptance of the site investigation as complete by the Division of Waste Management.

Two (2) copies of the CAP shall be submitted within forty-five (45) days of the date of receipt of the notice of the acceptance of the site investigation by the Division of Waste Management.

The purpose of the CAP is to outline the proposal for remediation of contaminated soils, air, surface water, sediment, groundwater, or bedrock impacted by the release of a regulated substance from a regulated UST system. The CAP shall be designed to reduce target chemical constituents to the allowable levels established for the site in the Facility Classification Outline, incorporated by reference in 401 KAR 42:080. This Corrective Action Plan Outline is provided to assist owners and operators in choosing remediation options that are appropriate to the geological and hydrogeological conditions at the site, within the context of the type and extent of contamination present at the site, and in determining whether the remediation options proposed are appropriate for meeting the allowable levels for target chemical constituents established for the site. For terms not defined herein, the definitions in 401 KAR 42:005 shall apply.

The CAP shall be, at a minimum, a conceptual plan of the proposed remediation system. This conceptual plan, shall address the following issues of concern:

- * the physical and chemical characteristics of the regulated substance, including its toxicity, persistence, and potential for migration;
- * the geologic and hydrogeologic characteristics of the site and the surrounding area;
- * the physical characteristics of all impacted and potentially impacted media at and surrounding the site, including soils, groundwater, surface water, sediment, air, and bedrock;
- * the full extent of contamination in all impacted media;

- * how the proposed corrective action will remediate the entire extent of contamination to the established site-specific clean up levels, including all media potentially impacted by the release or the remediation;
- * a proposed time table for the corrective action, including the anticipated time to achieve compliance;
- * the potential effects of residual contamination on nearby surface water and groundwater;
- * any exposure assessment conducted;
- * any information assembled in compliance with the Corrective Action Plan Outline;
- * any other requirements as detailed herein.

All technical issues related to the proposed remediation technology shall be addressed in the CAP. "As built" plans are not required to be submitted with the CAP.

Presumption of Acceptability of the CAP

Once the site investigation for a facility is determined by the Cabinet to be complete, a CAP is required to be submitted to the Cabinet within forty-five (45) days of receipt of the letter of acceptance of the site investigation by the Cabinet. If the Cabinet has not made a final determination as to the acceptability of the CAP within ninety (90) days of the receipt of the CAP by the UST Branch it shall be presumed that the CAP is acceptable to the Cabinet, and the CAP shall be implemented. This section does not apply to CAPs proposing "Risk Assessment" or "Monitoring Only" as a remedial option. Nothing in this section shall exclude the facility from the requirements for Public Notice, Notification of Implementation of the CAP, submission of the "As Built" Plan, Monitoring Requirements, Closure Plan Requirements, Quarterly Reports, or any other requirements of the Corrective Action Plan Outline. Nor does this preclude the possibility that the Cabinet may impose additional requirements subsequent to the presumption of acceptability. Nothing in this section shall relieve any person of any obligations imposed by law during an environmental emergency, nor shall it require the Cabinet to approve or accept a proposal which would violate any statute or administrative regulation. The presumption of acceptability applies only to corrective action plans that have been requested by the Cabinet.

Notification of Implementation of the CAP

Owners or operators shall begin implementation of the CAP within thirty (30) days of the date of acceptance of the CAP by the Cabinet. The Cabinet shall be informed in writing of the owner's or operator's intent to implement the CAP at least seven (7) days prior to implementation.

Public Notice Requirement

Prior to the implementation of the CAP the owner or operator shall give notice of the proposed action by publishing at least one time, a Public Notice in a newspaper having general circulation in the county where the corrective action is to take place. One (1) copy of the invoice and two (2) copies of an affidavit of publication shall be submitted to the Cabinet within seven (7) days of the publication. An example of the Public Notice that shall be completed and published is included at the end of this outline.

"As Built" Plan Requirement

Within one hundred twenty (120) days of the date of acceptance of the CAP by the Cabinet and after installation of the remediation system two (2) copies of the "As Built" plan shall be submitted to the Division.

The "As Built" Plan shall contain all relevant technical information concerning the remediation, including:

- * all equipment specifications;
- * site maps indicating the location of all related remediation equipment (all maps shall be to scale and shall include a north arrow and a legend);
- * the position of the remediation equipment relative to the extent of contamination;
- * copies of required permits; and
- * any other relevant technical information or other information required by the CAP Outline.

Monitoring Requirements

*** Quarterly Reporting Requirements**

Once the CAP has been implemented owners or operators shall submit a quarterly report of the corrective action activities within thirty (30) days after the close of each calendar quarter. The first quarterly monitoring report shall be submitted within one hundred twenty (120) days of the date of the acceptance of the CAP. The reports will be required until the site is closed by the issuance of a closure letter from the Cabinet. These quarterly reports shall include, but are not limited to, the following information: a site map with sampling locations indicated sample results, chain of custody documentation, monitoring data, liquid level data, system performance evaluations, discussion of any trends in data and/or performance, and any actions relating to the implementation of the corrective action. Note that, unless installed by a certified monitoring well driller in accordance with 401 KAR 6:310, piezometers shall not be used for the extraction of groundwater for any sampling purpose.

*** Groundwater Sample Analysis Form**

Facilities required to remediate or monitor groundwater shall submit to the Cabinet the results of all groundwater sample analyses using the UST Groundwater Sample Analysis Form (DEP2013 9/5/95). The first quarterly monitoring report shall be submitted within one hundred twenty (120) days of the date of the acceptance of the CAP. Additional groundwater monitoring reports are required to be submitted with the quarterly report thereafter.

*** Monitoring System Performance**

Two (2) copies of a system performance monitoring plan shall be submitted to the Cabinet that outlines how the performance of the remediation system is to be evaluated. In addition, a time table outlining benchmarks for remediation shall be presented in the CAP (if applicable).

Closure Plan Requirements

Two (2) copies of a Closure Plan shall be submitted to the Cabinet outlining the procedure used in determining that all remedial goals have been met for this site, and that any residual contamination is below the levels established for the site. The Closure Plan shall be submitted to the Cabinet within one hundred twenty (120) days of the last quarterly monitoring report indicating that residual levels of contamination have met the requirements for this site as outlined in the Site Facility Classification Outline for at least four (4) quarters. The Closure Plan shall include, at a minimum, four (4) quarters of clean groundwater samples from representative assessment wells, obtained after the corrective action system has been inactive (if applicable), and confirmatory soil

samples of the extent and perimeter of the previously delineated area of contamination. The type(s) of remedial system(s) being used shall be considered in developing the Closure Plan. In addition, temporal and geographic variations in site conditions must be accounted for in the proposed Closure Plan.

The Cabinet may deny or revoke acceptance of the corrective action plan for any UST facility because of incompleteness of the CAP, or the failure of the owner or operator to demonstrate that the proposed corrective action is appropriate, or the failure to demonstrate that the proposed corrective action will achieve clean-up goals established for the site, or the failure to demonstrate that the proposed corrective action will adequately protect human health, safety, and the environment.

Pursuant to 401 KAR 42:060 which incorporates 40 CFR 280.66 by reference, owners and operators may, in the interest of minimizing environmental contamination and promoting more effective cleanup, begin cleanup of soil and groundwater before the CAP is accepted provided that the UST Branch is notified in writing of the intention to begin cleanup. The UST Branch may impose conditions on the implementation of the interim actions. Owners and operators should be aware that certain types of corrective action, or a lack of remedial measures, may distribute the contamination or allow it to migrate into areas that were not previously effected by the release.

Pursuant to KRS 322 and KRS 322(A) any work constituting the public practice of engineering or geology, including the development and implementation of the corrective action plan, shall be completed by a Professional Engineer (P.E.) registered with the Kentucky Board of Registration for Professional Engineers and Land Surveyors, or a Professional Geologist (P.G.) registered with the Kentucky Board of Registration for Professional Geologists and the attached affidavit signed by same.

This outline provides a general format for preparing a corrective action plan. Some sites and some corrective action remediation technologies have unique features that may require additional information. The intent of this outline is to provide the minimum requirements for a CAP.

PART I. CORRECTIVE ACTION PLAN OUTLINE: GENERAL REQUIREMENTS

If the information required below has previously been submitted to the Division of Waste Management (e.g. in the Site Investigation and Closure Assessment reports, or other reports) this same information is not required to be resubmitted. The location of the information previously submitted (i.e. the name and date of the report, and the page numbers where the relevant information is located) shall be indicated in the CAP and on the CAP checklist.

1.0 SITE IDENTIFICATION AND LOCATION

- 1.1** Provide the site name, location, and the UST facility identification number.
- 1.2** Provide a topographic map depicting the location of the site. The map shall also indicate the surrounding properties and the nearest town, city, or community. Provide the USGS topographic quadrangle name in which the site is located.
- 1.3** Provide a detailed, site-specific map. The site map shall include a scale, north arrow, and legend. The site map shall illustrate tank and piping locations, the location and depth of all tank pits, the locations of property boundaries, adjacent properties and their land use, as well as other pertinent features. The estimated boundaries of the contamination shall be identified on the site map. The map shall also include any underground utility trenches, indicating the type of service and the depth of the trench. Site maps shall include all sampling locations, all monitoring locations (including groundwater, surface water, sediment, and air), the locations of all parts of any existing or proposed remediation system(s) including extraction wells, infiltration galleries, injection points, sparge nodes, soil vents, trenches, piping, pumps, scrubbers, separators, electrical conduits, or other equipment pertinent to the remediation system(s).
- 1.4** Provide the latitude and longitude for the site.
- 1.5** Provide original site photographs with descriptive captions, including features pertinent to the remediation activities at the site, in the original CAP report submitted to the Cabinet. The use of color photocopies of the original photographs will be acceptable in any additional copies of the CAP report required to be submitted.
- 1.6** Provide information on local population demographics of the area around the site, including information regarding land use on site and in the immediate surrounding area.

2.0 SITE HISTORY

- 2.1** Provide the location of the property including the street address, city, and county.
- 2.2** Provide the facility owner's name, address, and telephone number.
- 2.3** Provide the facility operator's and the property owner's name, address, and telephone number, if different than the facility owner's.
- 2.4** Provide a summary of all commercial and private activities that have been conducted at the site.
- 2.5** Provide a chronological description of all investigatory and corrective action work conducted to date.

- 2.6 Provide a summary of the climatological conditions from available sources (e.g. The United States Department of Agriculture Soil Conservation Service's Soil Survey for counties in Kentucky) for the site.

3.0 UNDERGROUND STORAGE TANK SYSTEM(S) HISTORY

- 3.1 Provide the age and size of all past and present underground storage tank systems at the site, the types of product(s) currently and previously contained in each system, the type of material of which all tanks and piping are constructed, the date tanks were last in operation, the conditions of all tanks and piping if they were removed, the dates of the tank and piping removals, any systems repair history, and the date of discovery of any release.
- 3.2 Provide a copy of leak detection records for the three (3) months prior to the discovery of the release or the discontinued use of tanks or piping, whichever is applicable. Present this information in a table format. If records are not available, a written explanation shall be submitted.

4.0 SUMMARY OF SITE INVESTIGATION(S)

- 4.1 Provide the date(s) of any regulated substance release(s), or the date(s) of the discovery of any such release(s), and the type and amount of product released.
- 4.2 Provide a summary of any emergency situations that have occurred as a result of the release of a regulated substance, such as fumes in homes, businesses, sewers, caves, etc., drinking water wells or lines impacted, explosions, fires, or any other emergency requiring a response. If ERT report(s) were filed relating to this release, summarize and provide the ERT numbers for each report.
- 4.3 Provide a description of the contaminants present and assess the degree of weathering of the product, if possible. The description shall include color and odor of contamination encountered, and shall include analytical profiles of the constituents of the contamination, if available.
- 4.4 Provide a summary of any actions taken to abate the release, methods used for free product recovery, and the amount of free product recovered.
- 4.5 Provide a description of methods currently being used to control migration of the contaminant plume(s).
- 4.6 Provide a summary of the results of the site investigation. This summary shall include a detailed map of the site illustrating the local topography and indicating the locations of sampling points, borings, and monitoring wells, and indicating groundwater flow direction, if applicable. A summary of lab and field sample analyses and "quality assurance/quality control" (QA/QC) data shall also be submitted.
- 4.7 Provide a map and cross sections constructed from soil borings and/or monitoring well borings, illustrating the horizontal and vertical contaminant gradients (e.g. isochem contours) at the site.

5.0 ADDITIONAL SITE CHARACTERIZATION

- 5.1** Provide a summary of any other physical, chemical, or biological data obtained as part of the site investigation, for example, soil porosity and permeability data, soil moisture data, soil gas data (e.g. CO₂, O₂, H₂S), physicochemical data (e.g. pH, Eh, soil and groundwater microbe enumeration studies, biomass calculations, or other information gathered that may be applicable, or necessary, for individual corrective action technology applications at the site.
- 5.2** Provide the results of any pumping tests, slug tests, or other aquifer tests conducted to characterize the groundwater at this site.
- 5.3** Provide the results of any other tests or analyses conducted to define the horizontal and vertical extent of contamination or to further characterize the site in order to determine the applicability or practicality of any specific remediation technology.

6.0 SOIL AND GROUNDWATER REMEDIAL OBJECTIVES

- 6.1** Provide the applicable proposed cleanup levels for soils at the site. These target levels shall be based on levels specified in the Division of Waste Management's Facility Classification Outline. Include a completed, signed, and dated copy of the Facility Classification Guide, indicating the Class and soil cleanup levels under which this site shall achieve closure (if applicable).
- 6.2** Provide the applicable cleanup levels for groundwater as determined from the Groundwater Worksheet in the Division of Waste Management's Facility Classification Outline, Groundwater Worksheet, incorporated in 401 KAR 42:080.

7.0 COMPARATIVE TECHNOLOGIES AND CORRECTIVE ACTION

- 7.1** Provide a summary of any alternative technologies given preliminary consideration for remediation at this site. The summary shall include a discussion of the applicability of the remediation considered, the treatability of the contaminants at the site given the contaminant and site conditions, the potential effectiveness of each technology given consideration, and why each technology was rejected as an alternative.
- 7.2** Provide a summary of any cost-effectiveness studies conducted on technologies given consideration as well as for selected technologies.
- 7.3** Include summaries of any pilot tests conducted for technologies given consideration but not selected in section 9.2. Data for pilot tests shall be submitted in an appendix.

8.0 SELECTED TECHNOLOGIES AND CORRECTIVE ACTION

- 8.1** Provide a summary of the technology (or technologies) selected for remediation at the facility and include a discussion of the criteria used to select this technology (e.g. time required for the treatment, ability to achieve cleanup levels).
- 8.2** Provide a schematic summary of the design and operation of the selected technology including a description of equipment, operating and monitoring requirements, and methods used to control discharges of air and/or water. This is intended to be a working conceptual plan and not an "as built" plan.

9.0 PILOT STUDIES

- 9.1** Provide a summary of the results of any pilot studies conducted, or models constructed, for any technology that was selected for site remediation, including field or laboratory data demonstrating that the technology can be expected to result in cleanup of the contamination. Data for pilot studies shall be provided in an appendix.
- 9.2** Provide a summary of the results of any pilot tests conducted on other technologies not selected for remediation at the site, which shall include field or laboratory data demonstrating why that technology cannot effectively reduce contaminant concentrations at the site to maximum allowable contaminant levels in soil and groundwater. Data for pilot studies shall be provided in an appendix.

10.0 MONITORING PLAN AND TIME TABLE FOR REMEDIATION AND CLOSURE

- 10.1** Provide a monitoring plan that shall include:
- a) a description of the parameters in soil and/or groundwater to be sampled (e.g. contaminant concentrations, soil-gas, soil pore-water and groundwater chemistries such as pH, Eh, O₂, COD) or other methods for determining corrective action efficacy at the site;
 - b) the locations of sampling points (e.g. monitoring wells, soil borings, soil gas surveys) that will be used to determine the location of and the extent of the contaminant plume(s), and the levels and activity within the contaminant plume;
 - c) a schedule for sampling selected parameters, including target contaminant concentrations, on a frequency sufficient to determine changes in contaminant levels and potential or real plume migration; at a minimum, required monitoring shall be conducted on a quarterly basis;
 - d) pursuant to 40 CFR 260.11, recognized methods in accordance with US EPA SW-846. These methods shall be followed for sample collection, sample preservation, sampling equipment, decontamination procedures, sample containers, sample size, maximum sample holding times, and sample analysis methods. Samples shall be delivered to an appropriate materials testing laboratory for the analysis required. The date the sample was collected, received, and analyzed by the laboratory, as well as all the US EPA SW-846 methods used to extract and analyze the sample, shall be indicated on the laboratory report. Refer to the Site Investigation Outline, incorporated by reference in 401 KAR 42:060, for the appropriate maximum acceptable reporting limits for target chemical constituent analytes.
 - e) chain-of-custody procedures. These procedures shall be followed to ensure the validity of all samples. The monitoring plan shall include the submittal of the chain-of-custody documentation that identifies who has had possession of the sample, the time of possession, and where the sample has been from the time it was collected until the laboratory accepts it. If the chain-of-custody is not maintained, e.g. if someone leaves a sample unattended, the integrity of the sample is compromised. The chain-of-custody shall follow all US EPA SW-846 requirements and shall be attached to all sample analyses results submitted;

- f) a plan of action if the plume is determined to have migrated beyond predetermined limits during corrective action and monitoring activity; and
 - g) a proposed time table for remediation, including proposed benchmarks delineating progress toward achieving the clean-up goals established for the facility.
- 10.2** Provide estimates of the rate of contaminant recovery expected from soil and/or groundwater based on pilot studies, mass balance projections, comparative analysis, or other available information. Tabulations and calculations performed to make these estimates shall be provided in an appendix.
- 10.3** Submit to the Division of Waste Management the first monitoring report within 120 days of the date of issuance of a letter by the Division notifying the owner or operator of the acceptance of the CAP. Monitoring reports are to be submitted minimally, on a quarterly basis.

11.0 CLOSURE PLAN

A closure plan shall be submitted that consists of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due migration of contamination and/or the production of daughter products. The closure plan shall also demonstrate that all monitor wells that will not be used for post-closure monitoring have been properly abandoned, upon closure, according to 401 KAR 6:310.

12.0 WASTE HANDLING, DISCHARGE, AND DISPOSAL

- 12.1** Provide copies of any discharge permits (or applications, or a plan to submit any required permits) required to perform the proposed corrective action(s), including pollution control permits, permits to discharge water to a local sewer, a local stream, or other body of water (Kentucky Pollutant Discharge Elimination System (KPDES)). Also, outline all anticipated discharge and disposal activities as a result of corrective action for this site.
- 12.2** Provide a plan for the proper disposal of any contaminated soils, residual tank materials, carbon filtration materials, residual waters, absorbent materials, or other materials generated as a function of the corrective action that require proper disposal.
- 12.3** Provide a plan to submit all disposal receipts and manifests (if applicable) for all material generated and disposed of during remedial activities and/or monitoring.

13.0 OFF-SITE ACCESS

Provide copies of signed contracts or other memoranda of agreement for permission to access and perform corrective actions on properties other than the property owned by the owner or operator of the underground storage tank system in consideration.

14.0 HEALTH AND SAFETY

Provide a copy of the standard operating health and safety plan to be followed through the course of the corrective action for the facility.

15.0 TECHNOLOGY-SPECIFIC CHECKLISTS AND CERTIFICATION AFFIDAVITS

- 15.1** Complete and submit all relevant checklist(s) and required information, specific to each technology, to be used as part or all of the remediation activities at the site.
- 15.2** Submit the certification affidavit to be completed, signed, stamped, and dated by the registered Professional Geologist (P.G.) or registered Professional Engineer (P.E.) certifying the corrective action plan and the information contained therein.
- 15.3** Submit the completed affidavit to be signed by the owner or operator and notarized.

16.0 PUBLIC NOTICE AND AFFIDAVIT, NOTIFICATION OF IMPLEMENTATION

- 16.1** The CAP shall include a plan to publish a public notice of the proposed corrective action, upon acceptance of the CAP by the Cabinet. The CAP shall include a plan to publish the public notice of proposed corrective action in a newspaper with general circulation in the county where the remediation is to take place, and shall include a plan to submit one copy of the invoice for publication, and two copies of an affidavit of publication to the Cabinet within seven days of the date of publication.
- 16.2** The CAP shall include a plan to submit to the Cabinet, in writing, a letter stating the intent of the owner or operator to implement the CAP that has been accepted by the Cabinet or has been presumed to be acceptable to the Cabinet.

17.0 "AS BUILT" PLAN

The CAP shall include a plan to submit to the Cabinet within one hundred twenty (120) days of the date of acceptance of the CAP by the Cabinet and after installation of the remediation system, an "As Built" Plan that includes all remediation and related equipment specifications, a site map indicating the location of the remediation equipment relative to the extent of contamination, copies of required permits, and any other relevant technical information.

18.0 SUBMITTAL OF THE CORRECTIVE ACTION PLAN

Two (2) copies of the CAP, including all relevant information and completed checklists, an affidavit signed by the owner or operator, the signed professional certification, and a copy of the public notice and two (2) copies of the affidavit of publication, shall be submitted within forty-five (45) days of the date of acceptance of the site investigation by the Division of Waste Management.

FINAL CORRECTIVE ACTION PLAN (CAP) REVIEW CHECKLIST (page 1)

The Final Corrective Action Plan Review Checklist is intended to aid the owner or operator and consultant in determining whether all the information required in the CAP is present. In addition, the intent of this checklist is to expedite review of the CAP by the UST Branch. If the information required below has previously been submitted to the Division of Waste Management (e.g. in the Site Investigation and Closure Assessment reports, or other reports) this same information is not required to be resubmitted. The location of the information previously submitted (i.e. the name and date of the report, and the page numbers where the relevant information is located) shall be indicated in the CAP and on the CAP checklist.

Site Name _____ County _____
Location _____ UST ID # _____

Instructions:

Indicate the page number next to the item included in the CAP report. Address any items not checked in the body of the report within the specific section. The complete checklist shall be submitted with each copy of the final report in order to expedite review of the corrective action plan.

- | Page # | | 1.0 SITE IDENTIFICATION AND LOCATION |
|--------|-----|--|
| _____ | 1.1 | Site name, location, and the UST facility identification number. |
| _____ | 1.2 | Site topographic map for exact location of the site (including a scale, a north arrow, legend, USGS quadrangle name, etc). |
| _____ | 1.3 | Detailed, site-specific map(s) for site location and information regarding the site (including scale, north arrow, legend, and locations of all pertinent features). |
| _____ | 1.4 | The latitude and longitude for site. |
| _____ | 1.5 | Original site photographs with descriptive captions. |
| _____ | 1.6 | Information on populations and land use for the site and the surrounding area. |
| | | 2.0 SITE HISTORY |
| _____ | 2.1 | Site street address, city and county. |
| _____ | 2.2 | Tank owner's name, address and telephone number. |
| _____ | 2.3 | Facility operator's and property owner's name, address, and telephone number. |
| _____ | 2.4 | Summary of commercial and private activities at the site. |
| _____ | 2.5 | Chronological description of all investigatory and corrective action work conducted to date. |
| _____ | 2.6 | Climatological conditions. |
| | | 3.0 UNDERGROUND STORAGE TANK HISTORY |
| _____ | 3.1 | Underground storage tank and piping information (all tanks past/present, age, size, contents, construction materials, tank and piping removal/upgrade dates, leak discovery date, repair history, etc.). |

FINAL CORRECTIVE ACTION PLAN (CAP) REVIEW CHECKLIST (page 2)

- ____ 3.2 Leak detection records for three (3) months prior to the release.

4.0 SUMMARY OF SITE INVESTIGATIONS

- ____ 4.1 Date of any release or release discovery, type and amount of product released.
____ 4.2 Summary of emergency situations as a result of a release (e.g. explosions, fires, fumes, etc.). Provide ERT reports and numbers.
____ 4.3 Description of contaminants present at site and an assessment of the degree of weathering.
____ 4.4 Summary of abatement actions, free-product recovery summary.
____ 4.5 Description of methods used to control contaminant plume migration.
____ 4.6 Summary of site investigation, including site map with sampling locations, borings, and monitoring wells. A summary of lab and field analyses, and QA/QC data.
____ 4.7 Site map and cross-sections illustrating horizontal and vertical extent of contamination.

5.0 ADDITIONAL SITE CHARACTERIZATION

- ____ 5.1 Summary of site characterization conducted for prospective corrective action technologies.
____ 5.2 Results of any pumping tests, slug tests, or other aquifer tests and characterization conducted.
____ 5.3 Results of any other tests, models, or analyses used to characterize the site relative to specific corrective action.

6.0 SOIL AND GROUNDWATER REMEDIAL OBJECTIVES

- ____ 6.1 Summary of cleanup levels for soils at the site, including a completed, signed, and dated Facility Classification Guide, indicating soil closure class as required by 401 KAR 42:080.
____ 6.2 Summary of cleanup levels for groundwater, including a completed, signed, and dated copy of the groundwater worksheet checklist, as included in 401 KAR 42:080.

7.0 COMPARATIVE TECHNOLOGIES AND CORRECTIVE ACTION

- ____ 7.1 Summary of the preliminary alternative technologies considered for remediation, including a discussion of contaminant conditions, applicability of the technologies and their treatability of contaminants, potential effectiveness, and a discussion as to why the technologies were rejected.
____ 7.2 Summary of any cost-effectiveness studies conducted.
____ 7.3 Summaries of any pilot tests conducted. (Data for pilot tests shall be included in an appendix.)

8.0 SELECTED TECHNOLOGIES AND CORRECTIVE ACTION

- ____ 8.1 Summary of proposed technology or technologies.
____ 8.2 Schematic summary of the design and operation of the remediation system.

FINAL CORRECTIVE ACTION PLAN (CAP) REVIEW CHECKLIST (page 3)

9.0 PILOT STUDIES

- _____ 9.1 Summary of the results of any pilot test conducted on proposed remedial technologies.
- _____ 9.2 Summary of the results of any pilot test conducted on alternative technologies not proposed.

10.0 MONITORING PLAN AND TIME TABLE FOR REMEDIATION AND CLOSURE

- _____ 10.1 Monitoring plan for the site, including quarterly reports, sampling parameters, sampling locations, sampling schedules, sampling methods and procedures, and alternative plan of action.
- _____ 10.2 Estimate of the rate of recovery of contaminants from the soil and/or groundwater.
- _____ 10.3 Time table for establishing and meeting remedial and closure objectives.
- _____ 10.4 Submission of the "As Built" Plan within 120 days of acceptance of the CAP.

11.0 CLOSURE PLAN

- _____ 11.0 Submit the Closure Plan that is proposed to determine that the extent of contamination has been remediated to the allowable levels established for the site, and monitor wells properly abandoned.

12.0 WASTE HANDLING, DISCHARGE, AND DISPOSAL

- _____ 12.1 Copies of, applications for, or plans to submit copies of any discharge permits required for closure and/or remediation at the site.
- _____ 12.2 Plan for disposal of soils, residual tank materials, absorbent materials, or other wastes generated during closure/remediation that require proper disposal.
- _____ 12.3 Plan to submit all waste disposal manifests and receipts.

13.0 OFF-SITE ACCESS

- _____ 13.0 Copies of contracts, memoranda of agreement, etc., allowing permission to the owner or operator or their agent to access and/or perform any required corrective action off site.

14.0 HEALTH AND SAFETY PLAN

- _____ 14.0 Copy of the health and safety plan for the facility.

15.0 CORRECTIVE ACTION PLAN CHECKLISTS

- _____ 15.1 Submit the appropriate checklists for each remedial technology to be employed at the site.
- _____ 15.2 Submit the certification affidavit to be completed by the registered Professional Geologist or registered Professional Engineer.
- _____ 15.3 Submit the owner or operator's affidavit, signed and notarized.

FINAL CORRECTIVE ACTION PLAN (CAP) REVIEW CHECKLIST (page 4)

16.0 PUBLIC NOTICE AND AFFIDAVIT

- _____ 16.1 Plan to submit one (1) copy of the public notice and two (2) copies of the affidavit.
- _____ 16.2 Plan to submit a notice to the Cabinet of the intent to implement the Corrective Action Plan.

17.0 "AS BUILT" PLAN

- _____ 17.1 Plan to submit two (2) copies of the "As Built" Plan to the Cabinet within one hundred twenty (120) days of the date of acceptance of the CAP by the Cabinet and after installation of the remediation system.

18.0 REPORT SUBMITTED

- _____ 18.0 An original and one (1) separate copy of the complete CAP shall be submitted with the UST facility identification number on the front page of each document.

CERTIFICATION OF THE CORRECTIVE ACTION PLAN

Under the requirements of KRS Chapters 322 and 322A, this Corrective Action Plan shall be completed and signed by a Professional Engineer (P.E.) registered with the Kentucky Board of Professional Engineers and Land Surveyors, or a Professional Geologist (P.G.) registered with the Kentucky Board of Registration for Professional Geologists.

Signature _____ Date _____

Name and Title (Type or Print) _____

Registration Number, Date, and Seal _____

The undersigned, first being duly sworn, states that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals responsible for obtaining the information, I believe the submitted information is true, accurate and complete. The undersigned further acknowledges that KRS 224.99-010 provides for penalties for submitting false information.

Company Name _____

Name and Title of Individual Whose
Signature Appears Below _____

Signature* _____

Date of Signature _____

Subscribed and sworn to before me by _____

This _____ Day of _____, 19____.

Notary Public _____

My Commission Expires _____

Location of Commission _____

*NOTE: If individual signing this is someone other than the president or secretary of a corporation, attach a notarized copy of power of attorney, or resolution of board of directors which grants individual the legal authority to represent the company. (Does not apply to a single proprietorship or partnership.)

PART II. TECHNOLOGY-SPECIFIC REQUIREMENTS

This section is designed to aid owners and operators and their consultants in determining whether each technology proposed for remediation at the site has been sufficiently evaluated for its applicability to site conditions and the full extent of contamination, and whether the corrective action plan (CAP) is complete. Technology-specific checklists are intended to aid owners and operators and their consultants in evaluating the completeness of the CAP. In addition, the CAP technology-specific checklists are intended to expedite review of the CAP by the UST Branch. The appropriate checklist for each proposed remedial technology shall be completed and submitted with the CAP.

System-specific information (e.g. equipment and operations specifications) are not required in the CAP. The CAP Outline is intended to aid owners and operators and their consultant in developing a reasonable and applicable 'working schematic plan' or 'conceptual model' that is based on sufficient information to substantiate the applicability of the proposed remediation to the site.

If any technology to be used is an 'innovative' technology (no technology-specific checklist is presented in the CAP Outline for the technology), the innovative technology checklist and any other relevant technical information regarding the proposed technology shall be completed and submitted with the CAP.

If "Monitoring Only" is proposed as the corrective action, the "Monitoring Only" checklist shall be completed and submitted with the CAP. "Monitoring Only" plans may be subject to review and acceptance by the Risk Assessment Branch of the Division of Environmental Services, Department of Environmental Protection.

Soil Vapor Extraction (SVE) CAP Checklist

Overview

Soil vapor extraction (SVE), also known as soil venting or vacuum extraction, is an *in situ* remedial technology that reduces concentrations of volatile constituents in petroleum products adsorbed to soils in the unsaturated (vadose) zone. In this technology, a vacuum is applied to the soil matrix to create a negative pressure gradient that causes movement of vapors toward the extraction wells. Volatile constituents can be readily removed from the subsurface through extraction wells. The extracted vapors are then treated, as necessary, and discharged to the atmosphere. This technology is commonly implemented as a dual-phase extraction (groundwater and soil air) using pump and treat technology or used as dual-phase extraction using a "liquid ring" pump.

SVE technology has been proven effective in reducing concentrations of volatile organic compounds (VOCs) and certain semi-volatile organic compounds (SVOCs) found in petroleum products at underground storage tank sites. SVE is generally more successful when applied to more volatile petroleum products such as gasoline. Diesel fuel, heating oils, and kerosene, which are less volatile than gasoline, are not readily treated by SVE but may be suitable for removal by other means (e.g. bioventing).

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

This checklist is provided to help evaluate the appropriateness of SVE to the remediation of the contamination at the site, to ensure the completeness of the CAP, and to expedite the review process. Submit the completed checklist with the CAP. Additional information may be required to determine if SVE will accomplish cleanup goals at this site, or a re-evaluation of alternative technologies may be required prior to submitting the CAP.

Answer the following questions and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Permeability of Soil

| Answer | Page # |
|--------|--------|
|--------|--------|

| | |
|-------|---|
| _____ | _____ What is the intrinsic permeability of the soil? |
|-------|---|

| | |
|-------|---|
| _____ | _____ What is the depth to groundwater? (If less than three (3) feet, this parameter alone may not negate the use of SVE. However, provisions for use of a surface seal, construction of horizontal wells, or for lowering the water table shall be incorporated in the CAP.) |
|-------|---|

Contaminant Constituent Volatility

Answer **Page #**

- _____ _____ What is the vapor pressure of each target contaminant?
- _____ _____ What, if applicable, is the type of enhancement to be used to increase the volatility of target contaminants (e.g. heated air injection)?
- _____ _____ What are the boiling points of the target contaminants?
- _____ _____ What is the Henry's Law constant for each target contaminant?

SVE System Design

Answer **Page #**

- _____ _____ What is the radius of influence (ROI) for the proposed extraction wells?
- _____ _____ What is the ROI calculated for each soil type at the site? (Include calculations in an appendix.)
- _____ _____ What are the proposed extraction flow rates? (Proposed extraction flow rates should achieve likely cleanup in the time allotted for remediation.)
- _____ _____ What types of wells (horizontal or vertical) are proposed for the site?
- _____ _____ Given the ROI for soil types and the area to be remediated, is the proposed well density appropriate?
- _____ _____ What are the proposed well-screen intervals and do they match the soil conditions at the site?
- _____ _____ What, if applicable, is the component proposed to intercept condensation or product (e.g. knockout pots) ahead of the blower?
- _____ _____ What precautions have been taken to prevent static buildup, static discharge, flashing, explosion, and fire?

Optional SVE Components

Answer **Page #**

- _____ _____ What type of inlet wells are proposed (e.g. air injection or passive)?
- _____ _____ Is the proposed air injection/inlet appropriate for the site?
- _____ _____ Are surface seals proposed?
- _____ _____ Are the sealing materials proposed appropriate for the site?
- _____ _____ Will groundwater table depression be necessary?

| | | |
|-------|-------|--|
| _____ | _____ | If groundwater table depression is necessary, are the pumping wells correctly spaced? |
| _____ | _____ | If groundwater is being discharged, is it necessary to treat the groundwater? |
| _____ | _____ | Have water discharge permits been obtained for water exiting discharge wells or the treatment process? |
| _____ | _____ | Is a vapor treatment system required? |
| _____ | _____ | If a vapor treatment system is required, is the proposed system appropriate for contaminant concentration at the site? |
| _____ | _____ | If necessary, have air discharge permits been acquired? |

Operation and Monitoring Plans

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Does the CAP propose daily monitoring for the first 7 to 10 days of flow measurements, vacuum readings, and vapor concentrations from each vapor extraction well, the manifold, and the effluent stock? |
| _____ | _____ | Does the CAP propose weekly to monthly monitoring of flow measurements, vacuum readings, and vapor concentrations from each vapor extraction well, the manifold, and the effluent stack? |
| _____ | _____ | Does the CAP propose that manifold valve adjustments be performed throughout the operation of the system to ensure unit stabilization and equitable vacuum extraction from each extraction well? |
| _____ | _____ | Does the CAP propose to submit monitoring reports on at least a quarterly basis? The first quarterly report shall be submitted to the Division of Waste Management within 120 days after the issuance of a letter by the Underground Storage Tank Branch accepting the submitted corrective action plan. |

Closure Plans

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP closure plan provide for testing soil-gas contaminant levels after the system has been shut down for a period sufficient to ensure that adsorbed phase contaminants will re-equilibrate with soil gases? |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory soil samples for closure? |
| _____ | _____ | Does the CAP closure sampling plan include collecting soil samples in those areas previously shown to be contaminated? (Meaning that the previously demonstrated horizontal and vertical extent of contamination be sufficiently sampled to determine that contamination in the soils has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure sampling plan include sampling locations at a distance sufficient from extraction wells to examine the perimeter effectiveness of each extraction well? |

Pump and Treat CAP Checklist

Overview

Pump and treat technology is commonly used to control plume migration and to remove groundwater from the subsurface. In this technology, a vacuum is applied via pumping below the saturated zone creating drawdown of the local groundwater table or piezometric surface and causing groundwater to move into the extraction wells. Contaminated groundwater can be readily removed from the subsurface through extraction wells then treated, as necessary, and discharged to streams, sewer lines, etc. or disposed at a proper facility.

This technology is used to remove and treat most types of petroleum contamination, as well as other hazardous contaminants with groundwater. Pump and treat technology has been shown to be nearly universally applicable at UST sites and effective in controlling plume migration and in reducing contaminant levels over time. Pump and treat is also used to control plume migration direction, groundwater flow direction and local groundwater elevations. Pump and treat is commonly used in conjunction with other technologies (e.g. soil vapor extraction, dual phase extraction using liquid ring pumps) as part of corrective action integrating multiple technologies toward achieving cleanup goals.

Pump and treat is most effective in reducing high levels of contamination over time. As a long-term treatment option, pump and treat technology is associated with relatively costly operations and maintenance requirements; however, this option may be necessary for the reduction of high contaminant levels in groundwater and as the only reasonable means to recover free product, control plume migration, or lower the local water table as necessary for other soil and groundwater remediation technologies.

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

This checklist is provided to help evaluate the appropriateness of the pump and treat technology to the remediation of the contamination at the site, to ensure the completeness of the Corrective Action Plan (CAP), and to expedite the review process. Submit the completed checklist with the CAP. Additional information may be required to determine if pump and treat will accomplish cleanup goals at this site, or a re-evaluation of alternative technologies may be required prior to submitting the CAP.

Complete the checklist below by answering the following questions and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Groundwater/Aquifer Characterization

| Answer | Page # |
|--------|--------|
|--------|--------|

| | | |
|-------|-------|---|
| _____ | _____ | Have groundwater tests, such as slug tests, pumping tests, or other tests, been conducted to indicate whether pumping groundwater will produce the desired effect (e.g. drawdown, or effective extraction of contaminated water?) |
|-------|-------|---|

| | | |
|-------|-------|---|
| _____ | _____ | Have the results of aquifer tests been included in the CAP (e.g. hydraulic conductivity, groundwater flow velocities, and storativity)? Calculations and graphs resulting from any aquifer test conducted at the site shall be submitted in an appendix to the CAP. |
| _____ | _____ | Do aquifer parameters indicate that the impacted groundwater at this site is conducive to pump and treat technology? |

Groundwater Extraction System

| Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | Do groundwater analyses indicate that equipment fouling is likely to occur? If yes, a plan for the pretreatment of groundwater shall be proposed. |
| _____ | _____ | Does the CAP provide maps showing the location of all extraction wells and piping? |
| _____ | _____ | Does the CAP describe the criteria that were used to determine the location of extraction wells and piping, including existing on-site wells? |
| _____ | _____ | Does the CAP explain how the zones of influence for the extraction wells have been determined? (Provide calculations of zones of influence in an appendix.) |
| _____ | _____ | Does the CAP provide the expected influent concentrations? (Include any calculations in an appendix.) |
| _____ | _____ | How was the expected drawdown calculated for recovery wells? (Provide all calculations in an appendix.) |

Groundwater Treatment System

For Air Stripping

| Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | What, if any, air treatment systems are proposed for the site? |
| _____ | _____ | What is the estimated mass-transfer coefficient? (Provide all calculations in an appendix.) |
| _____ | _____ | Is the treatment to take place in a non-attainment zone? |
| _____ | _____ | Is a air effluent permit required and has the permit been applied for or granted? |

For Carbon/Other Material Adsorption

| Answer | Page # | |
|---------------|---------------|--|
| _____ | _____ | Does the CAP describe the adsorption systems? |
| _____ | _____ | Has a complete description of the adsorption process been included in the CAP? |

| | | |
|-------|-------|---|
| _____ | _____ | Is pretreatment to be used on groundwater entering the adsorption unit? |
| _____ | _____ | Has a complete description of the pretreatment process been included in the CAP? |
| _____ | _____ | Does the CAP describe proposed system controls for the groundwater recovery and pretreatment and posttreatment systems? |
| _____ | _____ | Does the CAP include a plan for the disposal and replacement of spent carbon or other absorbent material? |

For Bioreactors

| Answer | Page # | |
|---------------|---------------|--|
| _____ | _____ | Does the CAP the describe the bioreactor system, including: - estimated biomass specifications? - estimated mass balance calculations for bioreactions? - estimated necessary contact time? (All calculations shall be included in an appendix.) |
| _____ | _____ | Is any pretreatment of groundwater entering the bioreactor necessary? |
| _____ | _____ | Does the CAP describe proposed system controls for the groundwater recovery and pretreatment and posttreatment systems? |
| _____ | _____ | Does the CAP describe system controls, such as recovery-well pump shutoff in case the bioreactor fails? |
| _____ | _____ | Does the CAP outline a plan for the disposal and replacement of the bioreactor? |

Discharge Permit Applications

| Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | Does the CAP propose a plan for obtaining and submitting applicable permits, including: |
| _____ | _____ | - KPDES or other surface water discharge permits? |
| _____ | _____ | - air emissions discharge permit? |
| _____ | _____ | - permit to dispose of contaminated carbon? |
| _____ | _____ | - disposal of bioreactor sludge? |
| _____ | _____ | - US EPA Underground Injection Control? |

Re-injection/Infiltration Galleries

Answer Page #

- _____ _____ Does the CAP propose that treated groundwater will be reintroduced to the subsurface as part of a flushing or bioremediation action? If so, the system is to be described in detail and any calculations included in an appendix?
- _____ _____ Does the CAP indicate that the US EPA Region IV Office, Underground Injection Control (UIC) will be notified that construction of injection wells or infiltration galleries is planned for this site? Generally, infiltration galleries do not require a permit; notification is sufficient.

Operation and Monitoring Plans

Answer Page #

- _____ _____ Does the CAP contain analyses of samples taken from each extraction well and each monitoring well within sixty (60) days of the date of submission of the CAP?
- _____ _____ Does the CAP propose a schedule for monitoring site conditions at start-up and during system operation (minimally on a quarterly basis), including:
- _____ - water table contours?
- _____ - extent of free product present?
- _____ - rates of recovery from influent wells?
- _____ - water quality parameters (*e.g.* hardness, TSS, TDS, pH, temperature, *etc.*)?
- _____ _____ Does the CAP propose a schedule for monitoring the progress of the remedial system?
- _____ _____ Does the CAP propose to submit monitoring reports on at least a quarterly basis?
- _____ _____ Does the monitoring plan in the CAP propose that sample analysis of all monitoring and extraction wells shall be submitted to the Division of Waste Management, minimally on a quarterly basis?
- _____ _____ Does the CAP propose to submit all groundwater analysis data using the UST Groundwater Sample Analysis Form (DEP2013 9/5/95)?
- _____ _____ Does the CAP contain an alternative plan if system performance monitoring indicates that pump and treat technology will not attain cleanup levels below the maximum allowable levels for contaminants in groundwater at the site or is not effective in controlling migration of the contaminant plume?

Closure Plans

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP closure plan provide for analyzing groundwater contaminant levels for a minimum of four (4) quarters after the system has been inactive? |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory groundwater samples for closure? |
| _____ | _____ | Does the CAP closure-sampling plan include collecting groundwater samples in those areas previously shown to be contaminated? (Meaning that the previously demonstrated horizontal and vertical extent of contamination in groundwater be sufficiently sampled to determine that contamination in the groundwater has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure sampling plan include sampling locations at a distance sufficient from extraction wells to examine the perimeter effectiveness of each extraction well? |

Air Sparging CAP Checklist

Overview

Air sparging is an *in situ* remedial technology that reduces the concentration of volatile hydrocarbons that are adsorbed to soils and dissolved in groundwater. The technology, which is also known as "*in situ* air stripping" and "*in situ* volatilization," involves the injection of contamination-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved or adsorbed phase to a vapor phase. The air is then vented through the unsaturated zone. Air sparging is most often used with soil vapor extraction (SVE), but it can also be used with other remedial technologies. When air sparging is combined with SVE, the SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration. This combined system is called AS/SVE. If air sparging is to be used in conjunction with any other technologies, the checklists relevant to the other technologies used shall also be completed and included in the CAP.

Since air-sparging technology is relatively new, there are few cases with substantial documentation of performance. When used appropriately, air sparging has been found to be effective in reducing volatile organic compounds (VOCs) found in petroleum products at underground storage tank (UST) sites. Air sparging is generally more applicable to lighter gasoline constituents (e.g. benzene, toluene, ethylbenzene, and xylenes [BTEX]), because they readily transfer from the dissolved phase to the gaseous phase. Air sparging is less applicable to diesel fuel, kerosene, and waste oil. Effective use of air sparging may require that it be combined with other remedial methods (e.g., SVE, bioventing, pump and treat).

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

This checklist is provided to help evaluate the appropriateness of air to remediate the contamination at the site and the completeness of the Corrective Action Plan (CAP). Submit the completed checklist with the CAP. Additional information may be required to determine if air sparging will accomplish cleanup goals at the site, or a re-evaluation of alternative technologies may be required prior to submitting the CAP.

Answer the questions and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Factors That Contribute to the Vapor/Dissolved Phase Partitioning of the Constituents

| Answer | Page # | |
|--------|--------|--|
| _____ | ____ | What is the Henry's law constant for each target chemical constituent? |
| _____ | ____ | What is the boiling point of each chemical target constituent? |
| _____ | ____ | What is the vapor pressure for each chemical target constituent? |

Permeability of Soil

| Answer | Page # |
|--------|--------|
|--------|--------|

- | | | |
|-------|-------|--|
| _____ | _____ | What is the intrinsic soil permeability of impacted soils? |
| _____ | _____ | Is the soil permeability isotropic or anisotropic? |
| _____ | _____ | What is the dissolved iron concentration in groundwater? |

Air Sparging System Design

| Answer | Page # |
|--------|--------|
|--------|--------|

- | | | |
|-------|-------|---|
| _____ | _____ | What is the radius of influence (ROI) for each of the proposed air sparging wells? |
| _____ | _____ | What is the ROI for each soil type at the site? (Submit any calculations in an appendix.) |
| _____ | _____ | Will the proposed extraction flow rates provide sufficient vapor/dissolved phase partitioning of contaminant constituents to achieve cleanup in the time allotted for remediation in the CAP? |
| _____ | _____ | Will the proposed air sparging pressure be sufficient to overcome the hydraulic head and capillary forces? |
| _____ | _____ | Will the proposed air-sparging pressure cause fumes to migrate into buildings, homes, etc.? |
| _____ | _____ | Are the number and placement of air sparging wells appropriate, given the total area to be cleaned up and the radius of influence of each well? |
| _____ | _____ | Are the proposed well-screen intervals sufficient to impact the contaminant plumes at the site? |
| _____ | _____ | Is the proposed well configuration appropriate for the site conditions present? |
| _____ | _____ | Have precautions been taken to prevent static buildup, static discharge, flashing, explosion, and fire? |

Operation and Monitoring Plans

| Answer | Page # |
|--------|--------|
|--------|--------|

- | | | |
|-------|-------|--|
| _____ | _____ | Does the site presently have any free product or fume problems? |
| _____ | _____ | Does the CAP propose operating an SVE system prior to starting the air sparging system? |
| _____ | _____ | If the answer to the previous question is 'yes', is the SVE checklist included in the CAP? |

| | | |
|-------|-------|--|
| _____ | _____ | Does the CAP contain a proposal to monitor system performance by measuring flow, vacuum readings, vapor concentrations, groundwater depth, dissolved oxygen levels, carbon dioxide levels, pH, or other constituents in extraction wells, monitoring wells, the manifold, and the effluent stack on a regular basis? |
| _____ | _____ | Does the CAP contain a proposal for monitoring VOC vapors in nearby buildings and other nearby enclosed spaces? |
| _____ | _____ | Does the CAP contain a proposal for monitoring groundwater pH and levels of contaminants, carbon dioxide, and dissolved oxygen in groundwater on a regular basis following startup? |
| _____ | _____ | Does the CAP contain a proposal for monitoring effluent stack for levels of contaminants, oxygen, and carbon dioxide on a regular basis following startup? |
| _____ | _____ | Does the CAP contain a proposal to submit monitoring reports on at least a quarterly basis? |

Closure Plans

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP closure plan provide for analyzing groundwater contaminant levels for a minimum of four (4) quarters after the system has been inactive? |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory groundwater samples for closure? |
| _____ | _____ | Does the CAP closure-sampling plan include collecting groundwater samples in those areas previously shown to be contaminated? (Meaning that the previously demonstrated horizontal and vertical extent of contamination in groundwater be sufficiently sampled to determine that contamination in the groundwater has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP propose to submit all groundwater analysis data using the UST Groundwater Sample Analysis Form (DEP2013 9/5/95)? |
| _____ | _____ | Does the CAP closure-sampling plan include sampling locations at a distance sufficient from sparge points to examine the perimeter effectiveness of each extraction well? |
| _____ | _____ | Does the CAP contain an alternative plan if system performance monitoring indicates that air sparging technology will not attain cleanup levels below the maximum allowable levels for contaminants in groundwater at the site or is not effective in controlling migration of the contaminant plume? |
| _____ | _____ | Does the CAP closure plan specify the methods for collecting and analyzing confirmatory groundwater samples for closure? |

Thin-spreading of Petroleum-Contaminated Soils or the "Registered Permit-by-Rule" CAP checklist

Overview

Thin-spreading is a potential remediation as part or all of the corrective action at UST sites with petroleum-contaminated soils. Thin-spreading, which is also known as "ex situ air stripping", "ex situ volatilization" and "ex situ biodegradation" involves the removal and relocation of contaminated soils to a treatment area. The soil is generally spread in thin layers and the contaminants are reduced through the processes of volatilization, hydrolysis, and biodegradation. Hydrocarbon-contaminated soils are commonly mixed with nutrients, microbes, and/or oxygen enhancers. Thin-spreading ideally maintains control of surface runoff, as well as seepage to the subsurface from the treatment area.

Thin-spreading is regulated by the Division of Waste Management, under the Registered Permit-by-Rule Regulation: 401 KAR 47:110. Under this regulation, in order to conduct thin-spreading of petroleum-contaminated soils "Notification for a Registered Permit-by-Rule" shall be obtained from, completed, and returned to the Division of Waste Management. To obtain a "Notification for a Registered Permit-by-Rule" contact the Underground Storage Tank Branch at:

Underground Storage Tank Branch
Division of Waste Management
14 Reilly Road
Frankfort KY 40601
(502) 564-6716

If petroleum-contaminated soils are to be treated at a permitted thin-spreading facility off site, the CAP shall contain a copy of the permit number, or the accepted "Notification for a Registered Permit-by-Rule" for the treatment facility. If contaminated soils are to be treated at a thin-spreading facility out of state, a receipt of disposal from the receiving facility shall be submitted to the Cabinet within one hundred twenty (120) days of the acceptance of the CAP.

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

Complete the checklist below, answering each question and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

| Answer | Page # | |
|--------|--------|--|
| _____ | ___ | Does the CAP propose to treat petroleum-contaminated soils by a thin spreading process? |
| _____ | ___ | Are petroleum-contaminated soils to be treated by thin-spreading at a permitted facility off site? |
| _____ | ___ | If soils are to undergo thin-spreading at a facility off site, what is the permit number for the facility? |

- _____ _____ If thin-spreading of the soils is to be conducted on site, has the UST Branch been contacted in order to receive the current requirements of the "Notification for a Registered Permit-by-Rule"?
- _____ _____ Does the CAP include a copy of the "Notification for a Registered Permit-by-Rule" submitted to the Division of Waste Management?
- _____ _____ Does the CAP include a copy of the letter of acceptance of the "Notification of Registered Permit-by-Rule" issued by the Division of Waste Management?
- _____ _____ Is the proposed treatment to occur in a non-attainment zone?
- _____ _____ Is an air emissions permit required for the proposed remediation as determined by the Division of Air Quality, and is the permit in the CAP?
- _____ _____ Are all other required or applicable checklists complete and included in the CAP?

Low Temperature Thermal Desorption (LTTD) CAP Checklist

Overview

Low-Temperature Thermal Desorption (LTTD), also known as low-temperature thermal volatilization, thermal stripping, and soil roasting, is an ex-situ remedial technology that uses heat to physically separate petroleum hydrocarbons from excavated soils. Thermal desorbers are designed to heat soils to temperatures sufficient to cause constituents to volatilize and desorb (physically separate) from the soil. Although they are not designed to decompose organic constituents, thermal desorbers can, depending upon the specific organics present and the temperature of the desorber system, cause some of the constituents to completely or partially decompose. The vaporized hydrocarbons are generally treated in a secondary treatment unit (e.g. an afterburner, catalytic oxidation chamber, condenser, or carbon adsorption unit) prior to discharge to the atmosphere. Afterburners and oxidizers destroy organic constituents. Condensers and carbon adsorption units trap organic compounds for subsequent treatment or disposal.

Some pre- and post-processing of soils is necessary when using LTTD. Excavated soils are first screened to remove large (> 2 inches in diameter) objects. These may be sized (e.g. crushed or shredded) and then introduced back into the feed material. After leaving the desorber soils are cooled, re-moistened to control dust, and stabilized (if necessary) to prepare them for disposal/reuse. Treated soil may be redeposited on site, used as cover in landfills, or incorporated into asphalt.

Thermal desorption systems fall into two general classes -- stationary facilities and mobile units. Contaminated soils are excavated and transported to stationary facilities; mobile units can be operated directly on site. Desorption units are available in a variety of process configurations including rotary desorber, asphalt plant aggregate dryers, thermal screws, and conveyor furnaces.

LTTD has proven very effective in reducing concentration of petroleum contamination in soils, including gasoline, jet fuels, kerosene, diesel fuel, heating oils, and lubricating oils. LTTD is applicable to constituents that are volatile at temperatures as great as 1200°F.

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

Answer the following questions and insert the page number(s) of the CAP where the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Evaluation of LTTD Effectiveness

| Answer | Page # |
|--------|--|
| _____ | ____ What is the plasticity of the soils to be treated? |
| _____ | ____ What is the maximum diameter of soil particles to be treated? |
| _____ | ____ What is the soil moisture content? |

_____ What is the total petroleum hydrocarbon concentration by weight in the soils to be treated?

_____ Is the volatility of the hydrocarbons present in soil and groundwater relatively low?

Determination if soils require pretreatment.

Answer Page #

_____ What is the concentration of humic material in the soils to be treated?

_____ What is the concentration of heavy metals (e.g. Pb, Cr) in the soils to be treated?

_____ What are K_{ow} 's for the target chemical constituents?

_____ Are dioxin precursors present in the soils?

It may be necessary that a pilot test or "test burn" be conducted to demonstrate that LTTD is an applicable remedial technology.

Answer Page #

_____ Do the results of the pilot test indicate that LTTD is applicable?

Evaluation of the Practicality of Using LTTD

Answer Page #

_____ What is the maximum depth to which the contaminated soils extend?

_____ Is the contaminated soil contained within the site boundaries?

_____ Is there contamination beneath buildings or near building foundations?

_____ Is excavation of the soil practical and cost-efficient to LTTD?

_____ Is sufficient land area available for operation of equipment and temporary storage (staging) of contaminated soil and treated soil to be treated on site?

_____ What is the distance to an off-site facility?

_____ Does surrounding land use permit operation of an on-site system?

Evaluation of the Effectiveness of Using LTTD

Answer Page #

_____ Have an adequate number of in-situ soil samples been collected and analyzed in order to delineate the extent of contamination?

_____ At what frequency are treated soil samples to be collected and analyzed?

- _____ Has the proposed desorption unit successfully treated soils with similar contaminant concentration levels?
- _____ What is the ultimate disposal location of the soil (e.g. return to excavation, transport to landfill for cover) proposed in the CAP?

Permitting, Monitoring, and Closure Requirements

- | Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | Has the Division for Air Quality been contacted to determine the current requirements for air emissions? |
| _____ | _____ | Does the CAP contain a copy of the permit or acceptance letter from the Division for Air Quality or a letter indicating that no permit is required? |
| _____ | _____ | Is a vapor treatment process proposed to treat emissions from the LTDD process? |
| _____ | _____ | Does the CAP include a proposed sampling plan of excavated soil prior to and following treatment, using the appropriate SW-846 sampling and analysis protocols? |
| _____ | _____ | Does the CAP contain a plan for the proper storage and transport for the excavated material before, during, and after treatment is included? |
| _____ | _____ | Does the CAP contain a closure sampling plan of the excavation(s), outlining sampling locations and protocols, and the methods of analysis? |
| _____ | _____ | Does the CAP include a proposal for sampling and analysis of any water encountered during excavation activities? |

Innovative Corrective Action Technologies CAP Checklist

Overview

This checklist shall be used for any technology for which a specific checklist is not provided in this outline. A thorough overview of the nature, processes, and status of any innovative technology proposed to be utilized at a UST site undergoing corrective action, whether as the sole technology, or in tandem, or in conjunction with any other remediation technology, shall be presented in the CAP. This discussion shall include: a summary of the application of the technology to the conditions at the site; a thorough presentation of the equipment and processes to be utilized; and how the system performance is to be monitored. In addition, a plan shall be submitted outlining the requirements of the CAP for monitoring the fate and transport of contaminants at the site during remediation. Also, a Closure Plan shall be submitted outlining a time-table for the corrective action and closure-sampling protocols, including the analytical methods to be used. The Division of Waste Management reserves the right to withhold approval of an innovative corrective action technology if sufficient information has not been presented to determine the appropriateness of the technology in relation to the site.

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

System Design

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP include a thorough overview of the proposed corrective action technology? |
| _____ | _____ | Does the CAP include a discussion of the applicability of the technology to the conditions at the site? |
| _____ | _____ | Does the CAP include a discussion of the application of the proposed technology to the treatability of the contamination at the site. |
| _____ | _____ | Does the CAP include the results of any pilot studies conducted regarding the application of the proposed technology at the site? |

Monitoring Plan

Answer Page #

- | | | |
|-------|-------|--|
| _____ | _____ | Does the CAP include a plan for the start-up and performance of the system? |
| _____ | _____ | Does the CAP include a plan for monitoring the levels and location of contaminants at the site during the remediation? (Monitoring reports shall be submitted minimally on a quarterly basis.) |

Closure Plan

Answer Page #

- | | | |
|-------|-------|---|
| _____ | _____ | Does the CAP include a plan outlining a time-table for remediation, which includes closure sampling protocols and analytical methods to be used? |
| _____ | _____ | Does the CAP closure plan provide for analyzing groundwater contaminant levels for a minimum of four (4) quarters after the system has been shut down? |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory groundwater samples for closure? |
| _____ | _____ | Does the CAP closure-sampling plan include collecting groundwater samples in those areas previously shown to be contaminated? (Meaning that the previously demonstrated horizontal and vertical extent of contamination in groundwater be sufficiently sampled to determine that contamination in the groundwater has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP propose to submit all groundwater analysis data using the UST Groundwater Sample Analysis Form (DEP2013 9/5/95)? |
| _____ | _____ | Does the CAP closure-sampling plan include sampling locations at a distance sufficient from treatment points to examine the perimeter effectiveness of each extraction well? |
| _____ | _____ | Does the CAP contain an alternative plan if system performance monitoring indicates that the proposed technology will not attain cleanup levels below the maximum allowable levels for contaminants in groundwater at the site or is not effective in controlling migration of the contaminant plume? |
| _____ | _____ | Does the CAP closure plan specify the methods for collecting and analyzing confirmatory groundwater samples for closure for four (4) quarters after the system has been inactive? |

Bioventing CAP Checklist

Overview

Bioventing is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. Soils in the capillary fringe and the saturated zone are not affected. In bioventing, the activity of the indigenous bacteria is enhanced by inducing air (oxygen) flow into the unsaturated zone (using extraction and/or injection wells) and, if necessary, by adding nutrients.

When extraction wells are used for bioventing, the process is similar to soil vapor extraction (SVE). However, while SVE removes constituents primarily through volatilization, bioventing systems promote biodegradation of constituents and minimize volatilization (generally by using lower air flow rates than for SVE). In practice, some degree of volatilization and biodegradation occurs when either SVE or bioventing is used.

All aerobically biodegradable constituents can be treated by bioventing. In particular, bioventing has proven to be very effective in remediating releases of petroleum products including gasoline, jet fuels, kerosene, and diesel fuel. Bioventing is most often used at sites with mid-weight petroleum products (e.g. diesel fuel and jet fuel) because lighter products (e.g. gasoline) tend to volatilize readily and can be removed more rapidly using SVE. Heavier products (e.g. lubricating oils) generally take longer to biodegrade than the lighter products.

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Site Characteristics

| Answer | Page # | |
|--------|--------|---|
| _____ | ___ | What is the intrinsic permeability of the soil? |
| _____ | ___ | Is the soil free of impermeable layers or other conditions that would disrupt air flow? |
| _____ | ___ | What is the heterotrophic bacteria count in dry soil? |
| _____ | ___ | What is the soil pH? |
| _____ | ___ | What is the moisture content of the soil in contaminated zones? |
| _____ | ___ | What is soil temperature during the proposed treatment season? |
| _____ | ___ | What is the intrinsic, or augmented carbon:nitrogen:phosphorus ratio? |

_____ What is the depth to groundwater?

Constituent Characteristics

Answer **Page #**

_____ Are all of the target chemical constituents sufficiently biodegradable?

_____ What is the approximate concentration of Total Petroleum Hydrocarbons in the soils (in ppm)?

_____ If there are constituents with vapor pressures greater than 0.5 mm Hg, boiling ranges above 300°C, or Henry's Law constants greater than 100 atm/mole fraction, has the CAP addressed the potential environmental impact of the volatilized constituents?

Evaluation of the Bioventing System Design

Answer **Page #**

_____ What is the radius of influence (ROI) for the proposed extraction or injection wells?

_____ What is the calculated ROI for each soil type at the site? (Include all calculations in an appendix of the CAP.)

_____ What types of wells (horizontal or vertical) are proposed for the site conditions?

_____ What is the well spacing relative to the calculated ROI of the soils?

_____ At what depths are the proposed well screen intervals?

_____ Are air injection wells proposed?

_____ What type of air injection well is proposed?

_____ Are the proposed air injection rates sufficiently low to prevent migration of the plume?

Optional Bioventing Components

Answer **Page #**

_____ Is nutrient delivery proposed?

_____ Is nutrient addition (if necessary) proposed to be controlled on a periodic or a continuous basis?

_____ Are surface seals proposed?

_____ Are the proposed sealing materials appropriate for the site?

_____ Will groundwater depression be necessary?

| | | |
|-------|-------|---|
| _____ | _____ | If groundwater depression is necessary, are the pumping wells correctly spaced relative to their ROI? (Include all calculations in an appendix to the CAP.) |
| _____ | _____ | Is a vapor treatment system required? |
| _____ | _____ | If a vapor treatment system is required, is the proposed system appropriate for the contaminant concentration at the site? |
| _____ | _____ | Does the CAP include a copy of any required permits, letters of approval for any air or water emissions resulting from remediation at the site? If no permit is required, a letter indicating such shall be submitted with the CAP. |

Operation and Monitoring Plan

| Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | Does the system performance monitoring plan propose monitoring of emission of VOC's and carbon dioxide concentration? |
| _____ | _____ | Is subsurface soil sampling proposed for tracking constituent reduction and biodegradation conditions? |
| _____ | _____ | Does the CAP contain a proposal to submit monitoring reports, at a minimum, on a quarterly basis? |

Closure Plan

| Answer | Page # | |
|---------------|---------------|---|
| _____ | _____ | Does the CAP include a plan outlining a time-table for remediation, which includes closure sampling protocols and analytical methods to be used? |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory soil samples for closure? |
| _____ | _____ | Does the CAP closure sampling plan include collecting soil samples in those areas previously shown to be contaminated? (Meaning that the previously demonstrated horizontal and vertical extent of contamination shall be sufficiently sampled to determine that contamination in the soils has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure sampling plan include sampling locations at a distance sufficient from extraction wells to examine the perimeter effectiveness of each extraction well? |

Site-Specific Risk Assessment CAP Checklist

Overview

Risk assessment may be conducted, as an option to remedial action at an UST site to determine whether the contaminant levels to remain at a UST site present an unacceptable risk to human health and the environment.

Site-specific risk assessment is reviewed by the Risk Assessment Branch of the Division of Environmental Services, 14 Reilly Road, Frankfort KY 40601, (502) 564-2150. Risk Assessment proposals for UST sites shall be submitted to the UST Branch, and these proposals will be referred to the Risk Assessment Branch for review. The UST Branch will notify the owner/operator of the findings of the Risk Assessment Branch.

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information. If site-specific risk assessment is to be used in tandem with any other technology, the checklists relevant to the other proposed remediation technologies shall be completed and included in the CAP.

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Has the UST Branch been contacted in order to receive a complete copy of the appropriate documents pertaining to Risk Assessment? |
| _____ | _____ | Has the Risk Assessment proposed been approved by the Risk Assessment Branch of the Division of Environmental Services? |
| _____ | _____ | Have all other applicable CAP checklists been completed and included in the CAP? |

Residual Landfill CAP Checklist

Overview

Residual landfill status includes leaving contamination in place. The levels of contamination allowed to be left in place remain above the levels required for closure under the Underground Storage Tank regulations. Residual landfills are regulated by the Division of Waste Management. The application requirements for residual landfills are found in 401 KAR Chapters 47 and 48. The technical requirements for residual landfills are included in 401 KAR 48:050 and 401 KAR 48:170. Residual landfills require a landfill cap and involve monitoring at the site. If part of the CAP is to eventually close the UST site as a residual landfill, a residual landfill permit shall be obtained from the Division of Waste Management. In order to obtain a residual landfill permit contact:

Division of Waste Management
14 Reilly Road
Frankfort KY 40601
(502) 564-6716

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Check the appropriate box.

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Has the Solid Waste Branch been contacted to determine the current permit requirements for residual landfills? |
| _____ | _____ | Is a copy of the residual landfill permit application submitted to the Solid Waste Branch enclosed? |
| _____ | _____ | Is a copy of the residual landfill permit issued by the Solid Waste Branch enclosed? |

Enhanced Bioremediation as an Option for Corrective Action

Overview

Biodegradation means degradation of organic compounds, in soil or groundwater, by indigenous, or introduced microbes. Enhanced Bioremediation is an application of biodegradation of organic compounds by microbes as a remediation when natural conditions have been altered to augment biodegradation at the site. Enhanced bioremediation may be a suitable remedial action at sites where the contaminants of concern are readily biodegradable, site conditions are favorable, and the time necessary for bioremediation to achieve cleanup levels in soils and groundwater is reasonable. However, limiting factors such as insufficient nutrients, depleted oxygen levels, or insufficient time exist at the site. Therefore microbial populations and microbial activity may require enhancement by the introduction of nutrients (e.g. nitrogen, phosphate), oxygen, other microbes, etc., in order to reduce contaminant levels in the amount of time considered acceptable for this corrective action, and/or to control plume migration. If artificial enhancement of microbial populations, nutrients, soils gases, etc. are required, this is known as "enhanced" bioremediation.

Site conditions may indicate that biodegradation of the contaminants present at the site will be sufficient to reduce contaminant levels and/or control plume migration without artificial enhancement; this is known as "naturally occurring" or "intrinsic" bioremediation. If intrinsic bioremediation is the only remedial method to be used at the site, the Monitoring Only CAP Checklist shall be used.

Application of enhanced bioremediation as a remediation technology requires that the site be evaluated to ensure that the site conditions are appropriate for the technology being proposed, that the technology proposed will not create resultant adverse conditions in the soil, air, or water, and that a sufficient monitoring plan be developed. Bioremediation can be a long-term remediation option; requiring years or decades to effect adequate cleanup of a site. Numerous factors affect the potential for and rate of bioremediation at a given site, such as:

- | | |
|--|---|
| * soil moisture content | * presence of suitable microbes |
| * porosity | * contaminants present and their concentrations |
| * soil temperature | * availability of nutrients |
| * soil pH | * presence of other electron receptors |
| * O ₂ availability | * redox potential (Eh) |
| * production of daughter products (e.g. MEK) | |

Because of the dependence on these factors, adequate site characterization is essential for determining the viability of bioremediation as an option for all, or part of, the corrective action at a given site. The characterization of a site for evaluation of bioremediation potential shall be part of the initial site investigation and involves:

- * characterization of the contaminants at a site;
- * assessment of physicochemical conditions at the site and the presence of appropriate nutrients; and
- * in some cases, assessment of microbiological parameters to determine the presence and viability of an appropriate microbial population may be necessary.

Characterization of site heterogeneity (e.g. anisotropic groundwater flow patterns, anisotropic soil permeability, etc.) and the potential for the further migration of contaminants shall be included in the site investigation. The number of samples necessary to adequately characterize a site for

bioremediation will vary based on the extent of contamination and the heterogeneity of the distribution of contamination at the site, and the heterogeneity of the soils and groundwater flow at the site.

Contaminant Characterization

Contaminants Present and Their Concentrations

It is important to identify the contaminants at a site, determine whether there is a potential for further migration of the contaminant plume, and determine whether the contaminants are readily amenable to bioremediation.

Degradation of most volatile compounds is inhibited whenever organic vapors are present in high concentrations in the soils and/or groundwater. Inhibited biodegradation may be due to either acute toxic effects and/or reduced oxygen levels. Acute toxicity to microorganisms is unlikely if residual levels of volatile organic compounds are less than several hundred mg/kg.

Biodegradability

Most petroleum hydrocarbons are readily biodegradable through aerobic metabolism. Many are also biodegraded by anaerobic metabolism, though at lower rates. In general the following are true:

- * Water-soluble compounds are usually degraded faster than less soluble compounds;
- * The n-alkanes, n-alkylaromatics, and aromatic compounds in the C₅ to C₂₂ range are usually readily biodegradable. These compounds comprise a major portion of gasoline and diesel fuel;
- * The n-alkanes, n-alkylaromatics, and aromatic compounds above C₂₂ have very low water solubilities which result in slower biodegradation rates. These compounds are found in heavier oils;
- * Condensed or fused aromatic and cycloparaffinic compounds with four or more rings have very low biodegradation rates. These include most of the PAH compounds; and
- * The rate of oxidation of straight-chain aliphatic hydrocarbons is inversely proportional to hydrocarbon chain length.

Environmental Parameters

Characterization of environmental parameters at a site is necessary to determine whether the physical and chemical conditions at the site are amenable to bioremediation, or whether conditions at the site need to be altered by introduced methods. The specific parameters that need to be evaluated for a given site shall be determined on a site-specific basis. These parameters may include the following:

- | | |
|--|--|
| * soil moisture content | * organic matter content (OM) |
| * soil moisture holding capacity/field capacity | * total organic carbon (TOC) |
| * soil porosity | * total organic nitrogen (TON) |
| * intrinsic soil permeability | * soil redox potential (Eh) |
| * bulk density of soil | * inorganic nitrogen (as NH ₃ , NO ₂ , NO ₃) |
| * soil pH | * soluble phosphorus (o-PO ₄) |
| * soil water dissolved oxygen | * "soluble manganese (Mn ²⁺) |
| * soil gas oxygen content | * iron (Fe ²⁺ , Fe ³⁺) |
| * storativity of impacted aquifer(s) | * sulfate (SO ₄ ²⁻) |
| * groundwater temperature | * plume migration rate and direction |
| * groundwater flow rate and direction | * hydraulic gradient |
| * hydraulic conductivity of impacted aquifer(s) | * groundwater dissolved oxygen |
| * porosity and permeability of impacted aquifers | * groundwater Eh |
| * aquifer isotropy/anisotropy | * groundwater Ph |
| * specific yield/specific retention of impacted aquifers | * homogeneity/heterogeneity of groundwater flow |
| | * availability of nutrients |

Microbiological Characterization

Assessing the presence of suitable microbes for degrading specific organic contaminants at a site is critical for implementation of bioremediation as a remedial action. Petroleum hydrocarbon-degrading microbes are widespread in the subsurface; in most cases they can be assumed to be present. However, some site conditions, such as marginal environmental conditions or high concentrations of contaminants or organic vapors, make it necessary to determine whether a viable microbial population is present. Based on the results of enumeration studies it may be determined that bioremediation is unsuitable at the site or that the microbe populations need to be enhanced by other methods.

Enumeration Studies

Microbial enumeration studies and column studies employ plate counts to determine relative numbers of total aerobic heterotrophs and total hydrocarbon degraders as qualitative measures for "clean" versus "contaminated" areas. These laboratory studies can provide evidence that the necessary microorganisms are present at a site and that metabolic adaptation has occurred. However, it is difficult to directly relate these studies to biodegradation potential, as laboratory conditions do not replicate site conditions. Enumeration studies are probably most useful for comparison of the areas of highest contamination, where aerobic microbial populations may be significantly reduced, to uncontaminated areas.

Respirometry

Respirometry is an indirect method for determining the presence of a viable microbial community at a site, and provides an indication whether *in situ* biodegradation is occurring at the site. Soil respirometry measures O₂ depletion/CO₂ production in the soil and can provide a measure of biological activity when compared with background measurements outside the zone of contamination at the site. Increased O₂ depletion/CO₂ production in the contaminated area relative to the background ratios indicates that aerobic biodegradation is occurring.

Monitoring Requirements

If the results of the site characterization indicate that bioremediation is appropriate to the site conditions and enhanced bioremediation is proposed as a remedial action, a monitoring plan shall be developed and implemented in order to evaluate the progress and effectiveness of bioremediation at the site. Monitoring shall serve several purposes:

- * to sufficiently monitor the entire extent of contamination;
- * to provide an indication that contaminant concentrations are decreasing over time;
- * to insure that the decrease in contaminant concentration is due to degradation, or other remedial processes ongoing at the site, and not due to contaminant migration or dilution;
- * to provide information regarding degradation rates; and
- * to provide data regarding the nature of biodegradation at the site.

From the standpoint of evaluating remediation effectiveness, the monitoring need not distinguish between biodegradation and abiotic degradation or loss of contaminants (such as volatilization, etc.) resulting from natural processes or other remedial efforts ongoing at the site (such as air sparging, soil vapor extraction, etc.).

Monitoring Plan

A variety of approaches and techniques are available for monitoring biodegradation and there is no set standard. A variety of approaches and/or techniques will likely be appropriate at most sites, especially if other remediation efforts are being used in conjunction with bioremediation. The monitoring plan shall be developed to address the nature of the contaminants and the physical conditions at the site.

Monitoring shall be conducted to ensure that any measured loss of contaminants is not due to migration or dilution.

The monitoring plan shall include at a minimum:

- * a description of the monitoring approaches and techniques to be used;
- * a description of the sampling plan (on a minimally quarterly basis);
- * establish benchmarks to monitor the progress of remediation;
- * the analytes to be sampled; and
- * the analytical methods to be used.

Monitoring Approaches

Change in concentrations of original contaminants

Confirmatory sample analysis for the target contaminants can be completed using the appropriate SW-846 methods. Soil and water samples may be taken from temporary constructions such as bore holes or direct-push methods. Water samples can be taken from permanent monitoring wells constructed at the site. The sampling shall monitor previously uncontaminated zones (both below and beyond the plume to ensure that decreases in contaminants have not been due to plume migration).

Change in concentration of co-reactants

Changes in the concentration of various nutrients (PO_4 , NH_4 , NO_2/NO_3), electron receptors (O_2 , NO_3 , $\text{Fe}^{3+,2+}$, $\text{Mn}^{4+,3+,2+}$, SO_4), and reaction by-products (CO_2 , CH_4 , N_2) can potentially provide information on the type and progress of biodegradation. These changes shall be compared to those in equivalent samples from outside the area of contamination to provide control.

Changes in physical and physicochemical properties, appropriate to the media being sampled, can be measured as well. These may include soil moisture content, soil/groundwater Ph, redox potentials, and temperature. Changes in these parameters can provide information for interpreting the other monitoring results.

All groundwater monitoring wells shall be analyzed minimally on a quarterly basis for the target contaminants, beginning within 120 days of receipt of a letter indicating that the CAP is acceptable.

Closure Plan

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants (using the appropriate SW-846 methods) in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080, and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of the contaminant plume(s) and/or the production of daughter products.

Enhanced Bioremediation CAP Checklist

This checklist is provided to help evaluate the appropriateness of the enhance bioremediation to the remediation of the contamination at the site and the completeness of the Corrective Action Plan (CAP). Submit the completed checklist with the CAP. Additional information may be required to determine how enhanced bioremediation will accomplish cleanup goals at this site, or a re-evaluation of alternative technologies is required prior to submitting the CAP.

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Contaminant Characterization

| Answer | Page # | |
|--------|--------|--|
| _____ | ___ | Are the contaminants present at the site likely to migrate off site? |
| _____ | ___ | Has all free product been recovered? |
| _____ | ___ | What are the petroleum hydrocarbon contaminant concentrations in the soils at the site? |
| _____ | ___ | What are the petroleum hydrocarbon contaminant concentrations in the groundwater at the site? |
| _____ | ___ | At what concentrations are organic vapors present in the soils at the site? |
| _____ | ___ | Are the target chemical constituents present at the site predominantly water-soluble? |
| _____ | ___ | Are the target chemical constituents present predominantly n-alkanes, n-alkylaromatics, and aromatic compounds in the C ₅ to C ₂₂ range? |

Environmental Parameters

| Answer | Page # | |
|--------|--------|--|
| _____ | ___ | What is the soil moisture content at the site as a percentage of the field capacity? |
| _____ | ___ | What is the air-filled pore space of soils at the site? |
| _____ | ___ | What is the saturated hydraulic conductivity for unsaturated zone soils (in cm/sec)? |
| _____ | ___ | What are the water-holding capacities of the soils at the site? |
| _____ | ___ | What is the range of soil temperatures at the site? |
| _____ | ___ | What is the range of groundwater temperatures at the site? |
| _____ | ___ | What is the range in intrinsic pH of the soils at the site? |

| | | |
|-------|-------|--|
| _____ | _____ | What is the range in intrinsic pH of the groundwater at the site? |
| _____ | _____ | What are the dissolved oxygen levels in contaminated groundwater at the site? |
| _____ | _____ | What is the redox potential, <i>Eh</i> , for the soils at the site? |
| _____ | _____ | What is the redox potential, <i>Eh</i> , for impacted groundwater at the site? |
| _____ | _____ | What is the total organic nitrogen content of soils at the site? |
| _____ | _____ | What is total organic nitrogen content of impacted groundwater at the site? |
| _____ | _____ | What is the carbon:nitrogen:phosphate ratio in the soils at the site? |
| _____ | _____ | Are other nutrients (e.g. K, Ca, Mg, S) found in adequate supply for metabolic needs in the soils and/or groundwater at the site? |
| _____ | _____ | If soil/groundwater oxygen levels are low, are other terminal electron acceptors present in the soil/groundwater that may be used for microbial metabolism? |
| _____ | _____ | What is the hydraulic conductivity of the contaminated groundwater at the site? |
| _____ | _____ | Has the groundwater flow rate and direction been determined? |
| _____ | _____ | Has the contaminant plume migration/dispersion rate and direction been determined? |
| _____ | _____ | Have all other relevant groundwater/aquifer parameters been determined in order that proper application and monitoring of enhanced bioremediation may occur? |

Microbial Characterization

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Has a viable microbial community been demonstrated in the soils/groundwater at the site either by enumeration studies, column studies, or respirometry? |
| _____ | _____ | Does the CAP include the results of enumeration studies or column studies conducted to determine the distribution of total aerobic heterotrophs and total hydrocarbon degraders in the soil/groundwater at the site? |
| _____ | _____ | Does the CAP include the results of any respirometry studies conducted to monitor microbial activity at the site? |

Enhancement Plan

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Is biostimulation proposed to be used? |
| _____ | _____ | What biostimulation technique is to be used? |

| | | |
|-------|-------|--|
| _____ | _____ | What is the source for O ₂ ? |
| _____ | _____ | What is the range of O ₂ ? |
| _____ | _____ | What is the source and supplier of other nutrients? |
| _____ | _____ | What is the electron receptor? |
| _____ | _____ | What were the initial ranges of nitrogen and phosphorous? |
| _____ | _____ | What are the target ranges for nitrogen and phosphorous? |
| _____ | _____ | Is the stoichiometric calculation of O ₂ demand included in the CAP? |
| _____ | _____ | Is bioaugmentation proposed to be used? |
| _____ | _____ | Do microbial population studies substantiate the need for bioaugmentation? |
| _____ | _____ | What is the source and supply of nutrients to be used? |
| _____ | _____ | What is the initial nitrogen:phosphorous ratio? |
| _____ | _____ | What is the target nitrogen:phosphorous ratio? |
| _____ | _____ | Does the plan for enhancing site conditions satisfy inadequate conditions noted in the site characterization or in the checklists above? |
| _____ | _____ | Does the plan for enhancing site conditions present a potential for causing migration of the plume beyond established acceptable boundaries? |
| _____ | _____ | Does the plan for enhancing site conditions present a potential for reducing concentrations of original contaminants by dilution? |

Monitoring Plan

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP propose to monitor nitrogen residuals? |
| _____ | _____ | Does the CAP propose to monitor potential migration of the plume beyond acceptable boundaries? |
| _____ | _____ | Does the CAP monitoring plan include a description of the monitoring approaches to be used? |
| _____ | _____ | Does the CAP monitoring plan include a description of the sampling plan? Sampling is to be conducted minimally, on a quarterly basis? |
| _____ | _____ | Does the CAP monitoring plan include a list of the analytes to be sampled? |
| _____ | _____ | Does the CAP monitoring plan include the sampling and analytical methods to be used? |

| | | |
|-------|-------|---|
| _____ | _____ | Will the CAP monitoring plan provide an indication that contamination is decreasing over time? |
| _____ | _____ | Can the CAP monitoring plan isolate any decrease in concentration due to degradation and not migration of the contaminants? |
| _____ | _____ | Does the CAP monitoring plan provide information regarding degradation rates? |
| _____ | _____ | Does the CAP monitoring plan provide information regarding the nature of degradation at the site? |
| _____ | _____ | Does the CAP monitoring plan include monitoring changes in concentration of original contaminants? |
| _____ | _____ | Does the CAP monitoring plan include monitoring changes in concentration of co-reactants such as various nutrients (PO_4 , NH_4 , NO_2/NO_3), electron acceptors (O_2 , NO_3 , $\text{Fe}^{3+}, 2+$, $\text{Mn}^{4+}, 3+, 2+$, SO_4), and reaction by-products (CO_2 , CH_4 , N_2)? |
| _____ | _____ | Does the CAP contain an alternative plan if system performance monitoring indicates that enhanced bioremediation will not attain cleanup levels below the maximum allowable levels for contaminants in groundwater at the site or is not effective in controlling migration of the contaminant plume? |

Closure Plan

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP closure plan provide for analyzing groundwater contaminant levels? |
| _____ | _____ | Does the CAP closure plan specify the methods for collecting and analyzing confirmatory groundwater samples for closure? |
| _____ | _____ | Does the CAP closure-sampling plan include collecting groundwater samples in those areas previously shown to be contaminated? (The previously demonstrated horizontal and vertical extent of contamination in groundwater be sufficiently sampled to determine that contamination in the groundwater has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory soil samples for closure? |
| _____ | _____ | Does the CAP closure sampling plan include collecting soil samples in those areas previously shown to be contaminated? (The previously demonstrated horizontal and vertical extent of contamination shall be sufficiently sampled to determine that contamination in the soils has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure-sampling plan include collecting soil and groundwater samples in those areas previously shown not to be contaminated? (Soil and groundwater on the perimeter of the previously demonstrated horizontal and vertical extent of contamination shall be sufficiently sampled to determine that reductions in contaminant concentration in the soil and groundwater have not resulted from migration.) |

Monitoring Only Plan (Intrinsic Bioremediation) as an Option for Corrective Action

Overview

Monitoring Only may be an option for remediation at UST sites if it can be demonstrated that the existing contamination at the site will not migrate beyond the point of compliance and the contamination will be attenuated by natural processes such as hydrolysis, volatilization, and naturally occurring biodegradation. In addition, in order for Monitoring Only to be a viable option for remediation at a UST Site, it must be demonstrated that the source of the contamination has been removed. Naturally occurring biodegradation means degradation of organic compounds, in soil or groundwater, by indigenous microbes. Intrinsic bioremediation may be a suitable remedial action at sites where the contaminants of concern are readily biodegradable, site conditions are favorable, and the time necessary for bioremediation to achieve cleanup levels in soils and groundwater is reasonable. In order to conduct a Monitoring Only Plan, contamination levels at the point of compliance shall not exceed the levels stipulated for this site in accordance with 401 KAR 42:080.

Microbial populations and microbial activity may require enhancement by the introduction of nutrients (e.g. nitrogen, phosphate) in order to reduce contaminant levels in the amount of time considered acceptable for this corrective action, and/or to control plume migration. If artificial enhancement of microbial populations, nutrients, soils gases, etc. are required, this is known as "enhanced" bioremediation. If "enhanced" bioremediation is to be implemented as a remedial method at the site, the Enhanced Bioremediation Cap Checklist shall be used.

Application of intrinsic bioremediation as a remediation technology requires that the site be evaluated to ensure that the site conditions are appropriate for the technology being proposed, that the technology proposed will not create resultant adverse conditions in the soil, air, or water, and that a sufficient monitoring plan be developed. Intrinsic bioremediation can be a long-term remediation option requiring years or decades to effect adequate cleanup of a site. Numerous factors affect the potential for, and rate of, bioremediation at a given site, such as:

- | | |
|---|---|
| * soil moisture content | * presence of suitable microbes |
| * porosity | * contaminants present and their concentrations |
| * soil temperature | * availability of nutrients |
| * soil pH | * presence of other electron receptors |
| * O ₂ availability | * redox potential (Eh) |
| * production of daughter products (e.g. MEK) | |

Because of the dependence on these factors, adequate site characterization is essential for determining the viability of intrinsic bioremediation as an option for corrective action at a given site. The characterization of a site for evaluation of intrinsic bioremediation potential shall be part of the initial site investigation and involves:

- * characterization of the contaminants at a site;
- * assessment of physicochemical conditions at the site and the presence of appropriate nutrients; and
- * in some cases, assessment of microbiological parameters to determine the presence and viability of an appropriate microbial population may be necessary.

Characterization of site heterogeneity (e.g. anisotropic groundwater flow patterns, anisotropic soil permeability, etc.) and the potential for further migration of contaminants shall be included in the site investigation. The number of samples necessary to adequately characterize a site for bioremediation will vary based on the extent of contamination and the heterogeneity of the distribution of contamination at the site, and the heterogeneity of the soils and groundwater flow at the site.

Contaminant Characterization

Contaminants Present and Their Concentrations

It is important to identify the contaminants at a site and determine whether there is a potential for off-site migration of contaminants, and whether the contaminants are readily amenable to bioremediation. Degradation of most volatile compounds is inhibited whenever organic vapors are present in high concentrations in the soils. This can be due to either acute toxic effects and/or reduced oxygen levels. Acute toxicity to microorganisms is unlikely if residual levels of volatile organic compound contaminants are less than several hundred mg/kg.

Biodegradability

Most petroleum hydrocarbons are readily biodegradable through aerobic metabolism. Many are also biodegraded by anaerobic metabolism, though at lower rates. In general the following are true:

- * Water-soluble compounds are usually degraded faster than less soluble compounds;
- * The n-alkanes, n-alkylaromatics, and aromatic compounds in the C₅ to C₂₂ range are usually readily biodegradable. These compounds comprise a major portion of gasoline and diesel fuel;
- * The n-alkanes, n-alkylaromatics, and aromatic compounds above C₂₂ have very low water solubilities which result in slow biodegradation rates; compounds are found in heavier oils;
- * Condensed or fused aromatic and cycloparaffinic compounds with four or more rings have very low biodegradation rates. These include most of the PAH compounds; and
- * The rate of oxidation of straight-chain aliphatic hydrocarbons is inversely proportional to hydrocarbon chain length.

Environmental Parameters

Characterization of environmental parameters at a site is necessary to determine whether the physical and chemical conditions at the site are amenable to intrinsic bioremediation. The specific parameters that need to be evaluated for a given site shall be determined on a site-specific basis. These parameters may include the following:

- | | |
|---|--|
| * soil moisture content | * organic matter content (OM) |
| * soil moisture holding capacity/ field capacity | * total organic carbon (TOC) |
| * soil porosity | * total organic nitrogen (TON) |
| * intrinsic soil permeability | * soil redox potential (Eh) |
| * bulk density of soil | * inorganic nitrogen (as NH ₃ , NO ₂ , NO ₃) |
| * soil pH | * soluble phosphorus (o-PO ₄) |
| * soil water dissolved oxygen | * "soluble manganese (Mn ²⁺) |
| * soil gas oxygen content | * iron (Fe ²⁺ , Fe ³⁺) |
| * storativity of impacted aquifer(s) | * sulfate (SO ₄ ²⁻) |
| * groundwater flow rate and direction | * plume migration rate and direction |
| * hydraulic conductivity of impacted aquifer(s) | * hydraulic gradient |
| * aquifer isotropy/anisotropy | * groundwater dissolved oxygen |
| * groundwater temperature | * groundwater Eh |
| * specific yield/specific retention of impacted aquifers | * groundwater pH |
| * homogeneity/heterogeneity of groundwater flow | * availability of nutrients |
| | * homogeneity/heterogeneity of soil porosity and permeability |

Microbiological Characterization

Assessing the presence of suitable microbes for degrading specific organic contaminants at a site is critical for implementation of bioremediation as a remedial action. Petroleum hydrocarbon-degrading microbes are widespread in the subsurface; in most cases they can be assumed to be present. However, some site conditions, such as marginal environmental conditions, or high concentrations of contaminants or organic vapors, make it necessary to determine whether a viable microbial population is present. Based on the results of enumeration studies it may be determined that bioremediation is unsuitable at the site.

Enumeration Studies

Microbial enumeration studies and column studies employ plate counts to determine relative numbers of total aerobic heterotrophs and total hydrocarbon degraders as qualitative measures for "clean" versus "contaminated" sites. These laboratory studies can provide evidence that the necessary microorganisms are present at a site and that metabolic adaptation has occurred. However, it is difficult to relate these studies to biodegradation potential directly, as laboratory conditions do not replicate site conditions. Enumeration studies are probably most useful for comparison of the areas of highest contamination, where aerobic microbial populations may be significantly reduced, to uncontaminated areas where normal microbial populations may exist.

Respirometry

Respirometry is an indirect method for determining the presence of a viable microbial community at a site, and provides an indication whether *in situ* biodegradation is occurring at the site. Soil respirometry measures O₂ depletion/CO₂ production in the soil and can provide a measure of biological activity when compared with background measurements outside the zone of contamination at the site. Increased O₂ depletion/CO₂ production in the contaminated area relative to the background ratios indicates that aerobic biodegradation is occurring.

Monitoring Requirements

If the results of the site characterization indicate that intrinsic bioremediation is appropriate to the site conditions and intrinsic bioremediation is proposed as a remedial action, a monitoring plan shall be developed and implemented in order to evaluate the progress and effectiveness of bioremediation at the site. Monitoring shall serve to:

- * sufficiently monitor the entire extent of contamination;
- * provide an indication that contaminant concentrations are decreasing over time;
- * insure that the decrease in contaminant concentration is due to degradation, and not due to contaminant migration or dilution;
- * provide information regarding degradation rates; and
- * it shall provide data regarding the nature of biodegradation at the site.

From the standpoint of evaluating remediation effectiveness, the monitoring need not distinguish between biodegradation and abiotic degradation, or loss of contaminants (such as volatilization, etc.) resulting from natural processes.

Monitoring Plan

A variety of approaches and techniques are available for monitoring biodegradation. A variety of approaches and/or techniques will likely be appropriate at most sites, especially if other remediation efforts are being used in conjunction with bioremediation. The monitoring plan shall be developed to address the nature of the contaminants and the physical conditions at the site. Monitoring shall be conducted to ensure that measured loss of contaminants are not due to migration or dilution.

The monitoring plan, at a minimum, shall include:

- * a description of the monitoring approaches and techniques to be used;
- * a description of the sampling plan (minimally on a quarterly basis);
- * establish benchmarks to monitor the progress of the remediation;
- * the analytes to be sampled; and
- * the analytical methods to be used.

Monitoring Approaches

Change in concentrations of original contaminants

Confirmatory sample analysis for the target contaminants can be completed using the appropriate SW-846 methods. Soil and water samples may be taken from temporary constructions such as bore holes or direct-push methods. Water samples can be taken from permanent monitoring wells constructed at the site. It is necessary that the sampling monitor previously uncontaminated zones (both below and beyond the plume) to ensure that decreases in contaminants have not been due to plume migration.

Change in concentration of co-reactants

Changes in concentration of various nutrients (PO_4 , NH_4 , NO_2/NO_3), electron receptors (O_2 , NO_3 , $\text{Fe}^{3+}, 2+$, $\text{Mn}^{4+}, 3+, 2+$, SO_4), and reaction by-products (CO_2 , CH_4 , N_2) can potentially provide information on the type and progress of biodegradation. These changes shall be compared to those in equivalent samples from outside the area of contamination to provide control.

Changes in physical and physicochemical properties, appropriate to the media being sampled, can be measured as well. These may include soil moisture content, soil/groundwater pH, redox potentials, and temperature. Changes in these parameters can provide information for interpreting the other monitoring results.

All groundwater monitoring wells shall be sampled and analyzed for the target contaminants minimally, on a quarterly basis.

Closure Plan

The closure plan shall consist of sampling soil and groundwater and analyzing for the target contaminants in a manner sufficient to ensure that all previously contaminated soils and groundwater are below the maximum allowable contaminant concentration levels established for this site in accordance with 401 KAR 42:080 and that any potentially impacted soils and/or groundwater have been sufficiently sampled to ensure that no secondary contamination has occurred due to migration of contamination and/or the production of daughter products.

Monitoring Only (Intrinsic Bioremediation) CAP Checklist

This checklist is provided to help evaluate the appropriateness of the enhance bioremediation to the remediation of the contamination at the site and the completeness of the Corrective Action Plan (CAP). Submit the completed checklist with the CAP. Additional information may be required to determine how enhanced bioremediation will accomplish cleanup goals at this site, or a re-evaluation of alternative technologies is required prior to submitting the CAP.

Answer the questions below and insert the page number(s) of the CAP on which the relevant information is included. If the relevant information is not included in the CAP, the CAP shall be amended to include the necessary relevant information.

Contaminant Characterization

| Answer | Page # | |
|--------|--------|--|
| _____ | ___ | Are the contaminants present at the site likely to migrate off site? |
| _____ | ___ | Has all free product occurring in soil and/or groundwater been recovered? |
| _____ | ___ | What are the petroleum hydrocarbon contaminant concentrations in the soils at the site? |
| _____ | ___ | At what concentration are organic vapors present in the soils at the site? |
| _____ | ___ | Are the target chemical constituents present at the site predominantly water-soluble? |
| _____ | ___ | Are the target chemical constituents present predominantly n-alkanes, n-alkylaromatics, and aromatic compounds in the C ₅ to C ₂₂ range? |

Environmental Parameters

| Answer | Page # | |
|--------|--------|--|
| _____ | ___ | What is the soil moisture content at the site as a percentage of the field capacity? |
| _____ | ___ | What is the air-filled pore space of the soils at the site? |
| _____ | ___ | What is the saturated hydraulic conductivity for unsaturated zone soils (in cm/sec)? |
| _____ | ___ | What are the water-holding capacities of the soils? |
| _____ | ___ | What is the range of the soil temperatures at the site? |
| _____ | ___ | What is the range of the groundwater temperatures at the site? |
| _____ | ___ | What is the range of the pH of the soils at the site? |
| _____ | ___ | What is the range of the pH of the groundwater at the site? |
| _____ | ___ | What are the dissolved oxygen levels in the contaminated groundwater at the site? |

| | | |
|-------|-------|---|
| _____ | _____ | What is the total organic nitrogen content of soils at the site? |
| _____ | _____ | What is the total organic nitrogen content of contaminated groundwater at the site? |
| _____ | _____ | What is the initial carbon:nitrogen:phosphate ratio in the soils at the site? |
| _____ | _____ | What is the target carbon:nitrogen:phosphate ratio in the soils at the site? |
| _____ | _____ | List any other nutrients (e.g. K, Ca, Mg, S) in soil and/or groundwater not present in adequate supply for microbial metabolic needs? |
| _____ | _____ | If soil/groundwater oxygen levels are low, are other terminal electron acceptors present in the soil/groundwater that may be used for microbial metabolism? |
| _____ | _____ | What is the hydraulic conductivity of the contaminated aquifer(s) at the site? |
| _____ | _____ | What are the groundwater flow rates and directions of the contaminated groundwater at the site? |
| _____ | _____ | What are the contamination migration/dispersion rates and directions at the site? |

Microbial Characterization

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Has a viable microbial community been demonstrated in the soils/groundwater at the site either by enumeration studies, column studies, or indirectly by respirometry? |
| _____ | _____ | Does the CAP include the results of enumeration studies and/or column studies conducted to determine the distribution of total aerobic heterotrophs and total hydrocarbon degraders in the soil/groundwater at the site? |
| _____ | _____ | Does the CAP include the results of any respirometry studies conducted to monitor initial microbial activity at the site? |

Monitoring Plans

| Answer | Page # | |
|--------|--------|--|
| _____ | _____ | Does the CAP propose to monitor nitrogen residuals? |
| _____ | _____ | Does the CAP propose to monitor potential migration of the plume beyond acceptable boundaries? |
| _____ | _____ | Does the CAP monitoring plan include a description of the monitoring approaches to be used? |
| _____ | _____ | Does the CAP monitoring plan include a description of the sampling plan? Sampling is to be conducted, at a minimum, on a quarterly basis, minimally. |
| _____ | _____ | Does the CAP monitoring plan include a list of the analytes to be sampled? |

| | | |
|-------|-------|---|
| _____ | _____ | Does the CAP monitoring plan include the sampling and analytical methods to be used? |
| _____ | _____ | Will the CAP monitoring plan provide an indication that contamination is decreasing over time? |
| _____ | _____ | Can the CAP monitoring plan isolate any decrease in concentration due to degradation and not migration of the contaminants? |
| _____ | _____ | Does the CAP monitoring plan provide information regarding degradation rates? |
| _____ | _____ | Does the CAP monitoring plan provide information regarding the nature of degradation at the site? |
| _____ | _____ | Does the CAP monitoring plan include monitoring changes in concentration of original contaminants? |
| _____ | _____ | Does the CAP monitoring plan include monitoring changes in concentration of co-reactants such as various nutrients (PO_4 , NH_4 , NO_2/NO_3), electron acceptors (O_2 , NO_3 , $\text{Fe}^{3+}, 2+$, $\text{Mn}^{4+}, 3+, 2+$, SO_4), and reaction by-products (CO_2 , CH_4 , N_2)? |
| _____ | _____ | Does the CAP contain an alternative plan if system performance monitoring indicates that intrinsic bioremediation will not attain cleanup levels below the maximum allowable levels for contaminants in groundwater at the site or is not effective in controlling migration of the contaminant plume? |

Closure Plan

| Answer | Page # | |
|--------|--------|---|
| _____ | _____ | Does the CAP closure plan provide for analyzing groundwater contaminant levels? |
| _____ | _____ | Does the CAP closure plan specify the methods for collecting and analyzing confirmatory groundwater samples for closure? |
| _____ | _____ | Does the CAP closure-sampling plan include collecting groundwater samples in those areas previously shown to be contaminated? (The previously demonstrated horizontal and vertical extent of contamination in groundwater be sufficiently sampled to determine that contamination in the groundwater has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure plan outline the methods for collecting and analyzing confirmatory soil samples for closure? |
| _____ | _____ | Does the CAP closure sampling plan include collecting soil samples in those areas previously shown to be contaminated? (The previously demonstrated horizontal and vertical extent of contamination shall be sufficiently sampled to determine that contamination in the soils has been reduced to below the maximum allowable levels for the site.) |
| _____ | _____ | Does the CAP closure-sampling plan include collecting soil and groundwater samples in those areas previously shown not to be contaminated? (Soil and groundwater on the perimeter of the previously demonstrated horizontal and vertical extent of contamination shall be sufficiently sampled to determine that reductions in contaminant concentration in the soil and groundwater have not resulted from migration.) |

EXAMPLE PUBLIC NOTICE

Kentucky Department for Environmental Protection
Division of Waste Management
Underground Storage Tank Branch
14 Reilly Road
Frankfort, Kentucky 40601

NOTIFICATION OF PROPOSED CORRECTIVE ACTION PLAN

The (UST site name, UST identification number), located at (address: Street, City, County, Kentucky) has proposed a plan to clean up (type of contamination) contamination from the (impacted media).

An underground storage tank system caused a release of (regulated substance released). A site investigation has been completed to determine the horizontal and vertical extent of contamination in the environment.

Proposed corrective measures include (technology or technologies to be used). The proposed activities are designed to restore the environment to its original condition prior to contamination.

The Kentucky Department for Environmental Protection proposes to accept the Corrective Action Plan. This decision is based on a thorough review of site conditions, Kentucky statutes and regulations.

Copies of the Corrective Action Plan are available from the Division of Waste Management at the above address or by contacting the Records Custodian for the Underground Storage Tank Branch at (502) 564-6716 or (800) 928-4273. Persons wishing to submit written comments on the Corrective Action Plan should direct them to the Division of Waste Management within thirty (30) days after publication of this notice.

Upon request, the Cabinet will provide a copy of the Corrective Action Plan in an alternate format.